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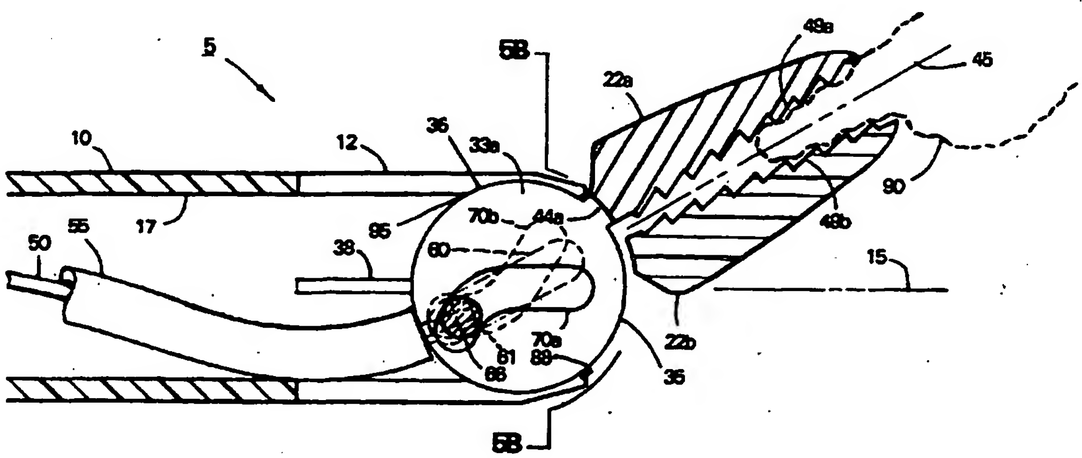


(57) Abstract

This invention is a surgical instrument (5) for gripping tissue in an endoscopic work space. The instrument has an elongate introducer sleeve (10) extending along a primary axis (15). An articulating jaw assembly (20) is coupled to the distal end of the introducer sleeve with a ball and socket-type joint (35, 36) that provides jaws (22a, 22b) that open and close around a secondary axis (45). The instrument further has a "flex jaw" feature (150a, 150b) whereby the jaw working faces (149a, 149b) are somewhat free to rotate relative to the jaw arms (142a, 142b). In another version, an elongate introducer sleeve (410) carries a distal jaw structure incorporating cooperating rolling tracks (445a, 445b) with tissue gripping serration (449) for applying continuous traction on the tissue.

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# ENDOSCOPIC SURGICAL INSTRUMENT

## BACKGROUND OF THE INVENTION

### Field of the Invention

This invention relates to surgical instrumentation and more particularly to an instrument for gripping and retracting tissue in an anatomic workspace.

### Description of Prior Art

In a "minimally invasive" endoscopic surgery, for example in the abdominal cavity, all instrumentation is introduced through cannulas that are in stationary positions in the abdominal wall sometimes making it difficult to retract or reposition anatomic structures with elongate instruments (e.g., grippers). Two common problems are related to the rigid jaws found in commercially available gripping instruments. A first problem may be described with reference to an endoscopic cholecystectomy (gall bladder removal). It is necessary to retract the gall bladder laterally, that is, by swinging the instrument lateral to its axis rather moving the instrument axially. On occasion, such lateral movement will cause a distalmost tip of a jaw to perforate a wall of the gall bladder thus causing bile to spill into the abdominal cavity which is undesirable. Second, sometimes such rigid pivoting jaws will crush or perforate tissue in the proximalmost portion of the jaws while not yet firmly engaging tissue in the distalmost portion of the jaws which also is undesirable.

To avoid the above-described types of tissue damage, current practice often requires cannula placements that will insure that retraction forces are generally applied axially with respect to the cannula and the instrument disposed therein. Thus, it is

sometimes necessary to make incisions for cannulas in difficult locations. It sometimes is necessary to make additional incisions for additional cannulas which also is undesirable. There is therefore a need for new instruments for gripping and retracting tissue in an endoscopic workspace.

## SUMMARY

An instrument of the present invention has an elongate introducer sleeve that is coupled to an articulating jaw assembly by a ball and socket-type joint that allows the jaw assembly to articulate and rotate about a second axis relative to the primary axis of the introducer sleeve. Thus, when tissue is engaged within the jaws, lateral retraction forces will cause the jaw assembly to articulate and the secondary axis of the jaw assembly will align itself with the direction of retracting forces. A trigger within a proximal handle actuates the jaws in any articulated position.

This instrument further includes a "flex jaw" feature, by which is meant the jaw working faces are somewhat free to rotate relative to the jaw arms. Thus, as the jaw arms close to engage tissue, the jaw working faces rotate to accommodate tissue thickness and density thereby uniformly applying engaging pressures. The "flex-jaw" feature results from a plurality of pivoting points associated with the jaw assembly. The jaw arms open or close around a first proximal pivot while the jaw working faces rotate within limits around a second distal pivot.

In general, this instrument provides an instrument for gripping and retracting tissue in which the jaw working faces close on an axis that will articulate to align itself with the direction of retraction forces. The present invention also provides an instrument in

which the jaw assembly may rotate about the axis defined by the jaw assembly relative to the axis defined by the introducer member.

The present invention provides an instrument for retracting tissue in which the articulating jaw assembly is self-centering when the jaws are in an open position to align the secondary axis of the jaw assembly with the primary axis of the introducer member. The present invention also provides an instrument in which the articulating jaw assembly is self-centering when the jaws are in a closed position in the absence of retracting forces. The present invention also provides an instrument permitting the jaws to be locked in any articulated configuration after the jaws have engaged tissue. The present invention also provides an instrument that allows the secondary axis defined by the jaw assembly to be locked in parallel alignment with the primary axis of the elongate introducer member.

The present invention provides an instrument for gripping tissue that includes a "flex jaw" feature for applying engaging pressure on tissue uniformly over the jaw working ends regardless of the thickness of the engaged tissue. The present invention also provides an instrument in which the jaw working faces apply engaging pressure on tissue by utilizing a first pivot for rotating the jaw arms and a second pivot for rotating the jaw working faces.

Also, in accordance with the present invention for applying traction on tissue in an endoscopic workspace, a traction-applying instrument includes an elongate introducer sleeve that carries a distal jaw structure incorporating cooperating "rolling tracks" having tissue-gripping serrations for applying continuous traction on tissue. The handle includes a jaw-actuating mechanism to close the jaws and the rolling

tracks around tissue and to maintain the jaws in any pivoted position. The handle further includes a track drive mechanism to roll the rolling tracks. Thus, counter-rotation of the cooperating tracks causes tissue to be progressively gripped and pulled into the "throat" or bore of the introducer sleeve. The jaws are double-pivoting whereby the jaw working ends rotate around distal pivots and the jaw forearms rotate around proximal pivots thus providing rolling tracks that remain generally parallel no matter the thickness of the tissue engaged.

The handle includes a 360° drive mechanism that is particularly suitable for endoscopic instruments and includes flexible bows adapted for squeezing. Applying and releasing inwardly-directed force on the bows causes the proximal part of the handle to separate from the distal part of the handle, thus reciprocating a track drive member that rolls the rolling tracks. The handle includes a plurality of opposing bows so that the surgeon may rotate the instrument 360° to align the jaws with tissue and thereafter actuate the drive mechanism in any angular position with a simple squeezing force.

A second embodiment of the traction instrument includes an elongate introducer sleeve with a single "rolling track" that may be pressed against delicate tissue to continuously apply traction. The rolling track is rolled unidirectionally by successively actuating a drive mechanism, thus retracting tissue progressively without axial movement of the instrument. The axis of the rolling track also may be articulated from the axis of the introducer sleeve to better engage tissue planes that lie at an angle relative to that of the introducer sleeve.

In general, the present invention provides an instrument and method for applying progressive

intracorporeal traction on tissue without manipulation of the instrument relative to its axis. The present invention provides an instrument and method for applying intracorporeal traction on tissue with a rolling track that incorporates tissue-gripping serrations. The present invention also provides an instrument with cooperating first and second rolling tracks incorporated into a opposing jaws for engaging tissue from opposing sides to apply intracorporeal traction. The present invention provides an instrument with cooperating first and second rolling tracks that retracts tissue into a "throat" or bore of the instrument for removal from an endoscopic workspace.

The present invention provides an instrument for applying intracorporeal traction on tissue that includes a double-pivot jaw structure that maintains the jaw working ends generally parallel from one another to grip tissue uniformly over the jaw working ends regardless of the thickness of the engaged tissue. The present invention also provides an instrument in which the jaw working ends may be releasably locked in any parallel position for any particular thickness of tissue. The present invention provides a handle with a drive mechanism that may be actuated with a single hand by squeezing inwardly on the handle no matter how the handle is rotated.

Additional advantages and features of the invention appear in the following description in which several embodiments are set forth.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of an articulated jaws instrument in accordance with the present invention.

FIG. 2 is an exploded isometric view of an assembly of the instrument of FIG. 1 taken along line

2-2 of FIG. 1 rotated 90°

FIG. 3A is a longitudinal partial sectional view of the assembly of FIG. 2 taken along line 3A-3A of FIG. 2 in a certain position.

FIG. 3B is a transverse sectional view of the assembly of FIG. 3A taken along line 3B-3B of FIG. 3A.

FIG. 4A is a longitudinal partial sectional view of the assembly of FIG. 2 taken along line 3A-3A of FIG. 2 in an alternative position.

FIG. 4B is a transverse sectional view of the assembly of FIG. 4A taken along line 4B-4B of FIG. 4A.

FIG. 5A is a longitudinal partial sectional view of the assembly of FIG. 2 taken along line 3A-3A of FIG. 2 in an alternative position.

FIG. 5B is a transverse sectional view of the assembly of FIG. 5A taken along line 5B-5B of FIG. 5A.

FIG. 6A is a longitudinal partial sectional view of the assembly of FIG. 2 taken along line 3A-3A of FIG. 2 in an alternative position.

FIG. 6B is a transverse sectional view of the assembly of FIG. 6A taken along line 6B-6B of FIG. 6A rotated 90°.

FIGS. 7-8 are longitudinal sectional views illustrating a component part of the subassembly of FIG. 2 taken along line 7-7 of FIG. 2 in alternative positions.

FIG. 9 is a longitudinal partial sectional view of a second embodiment of gripping assembly similar to the views of FIGS. 4A-6A.

FIG. 10 is a longitudinal partial sectional view of the assembly of FIG. 9 in another position.

FIG. 11 is a longitudinal partial sectional view of the assembly of FIG. 9 in yet another position.

FIG. 12 is an isometric view of a component part of the second embodiment of FIG. 9.

FIG. 13 is a partial sectional view of the handle

of the second embodiment referred to in FIGS 9-12.

FIG. 14 is a partial sectional view of a portion of a third embodiment of gripping instrument.

FIG. 15 is an elevational view of a first embodiment of the present traction applying instrument in accordance with the invention.

FIG. 16 is an isometric view of a portion of the instrument of FIG. 15 taken along line 2-2 of FIG. 15 rotated 90°.

FIG. 17 is a longitudinal partial sectional view of a portion of FIG. 16 taken along line 3-3 of FIG. 16.

FIG. 18 is a longitudinal partial sectional view similar to FIG. 17 in another position.

FIG. 19 is a longitudinal partial sectional view similar to FIG. 17 in another position.

FIG. 20 is a longitudinal partial sectional view of the handle of the instrument taken along line 6-6 of FIG. 15 rotated 90°.

FIG. 21 is a partial sectional of the handle of FIG. 20 in another position.

FIG. 22 is a transverse sectional view the handle taken along line 8-8 of FIG. 20.

FIG. 23 is a transverse sectional view the handle taken along line 9-9 of FIG. 21.

FIG. 24 is an enlarged sectional view of the drive mechanism within the handle taken along line 10-10 of FIG. 20.

FIG. 25 is a partial longitudinal sectional view of an alternative embodiment of a handle and drive mechanism.

FIG. 26 is a partial sectional view of the handle and drive mechanism of FIG. 25 in another position.

FIG. 27 is a partial sectional view of a second embodiment of the rolling track jaws invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

1. Articulated Flex Jaws Instrument

By way of example, FIG. 1 depicts instrument 5 with handle assembly 8 coupled to elongate introducer sleeve 10. Sleeve 10 with proximal and distal ends respectively 11 and 12, has a cylindrical shape extending along axis 15 with an overall length of approximately 200 mm. (not limiting). The outside diameter of sleeve 10 is approximately 10 mm. (not limiting) to cooperate with a standard 10-11 mm. inside diameter cannula. Sleeve 10 is made of any suitable material such as injection-molded plastic or a combination of metal and plastic. Bore 17 extends through sleeve 10.

Referring to FIGS. 1-2, jaw assembly 20 is carried at distal end 12 of sleeve 10 and includes cooperating left-hand and right hand jaw elements, 22a and 22b, respectively. The jaw elements, 22a and 22b, are made of any suitable material such as e.g. injection-molded plastic or metal. Actuator disc 25 fits between jaw elements, 22a and 22b, and disc 25 is made of e.g. an injection-molded plastic that has resilient characteristics, such as Delrin. The proximal hemispherical portions 32a and 32b of jaw elements 22a and 22b have opposing flat faces 33a and 33b respectively. The assembly of proximal hemispherical portions 32a and 32b of the jaw elements together with actuator disc 25 form a spheroid-shaped portion 35 of assembly 20 (see FIGS. 3A-3B).

Spheroid-shaped portion 35 of assembly 20 slip fits in cooperating spheroid-shaped socket 36 formed within distal end of bore 17 of sleeve 10 (see FIGS. 2 and 3A-3B). A plurality of longitudinal slots 38 allow for flexing of longitudinally-extending socket portions 39 in sleeve 10. Such socket portions 39 may flex slightly radially outward to insert spheroid-shaped

portion 35 into spheroid-shaped socket 36. Thus, jaw assembly 20, and more particularly spheroid-shaped portion 35, may articulate and rotate in socket 36.

Referring to FIG. 2, jaw elements 22a and 22b have distal jaw arms 42a and 42b. Arms 42a and 42b are connected to proximal hemispherical portions 32a and 32b, respectively, by web portions 44a and 44b. The jaw elements, and more particularly the jaw arms 42a and 42b, converge on or separate from secondary axis 45 of jaw assembly 20. The arms of each jaw element are configured to extend laterally across secondary axis 45 such that working faces 49a and 49b mate symmetrically relative to secondary axis 45 (see FIGS. 2 and 6A).

A mechanism is provided to actuate jaw assembly 20 between an open position (see FIG. 3A) and a closed position (see FIG. 4A). The jaw actuating mechanism includes flexible cable 50 with proximal and distal ends respectively 51 and 52, that extends through flexible cable housing 55. Cable 50 is made of any suitable material such as braided stainless steel and extends through aperture 57 in actuator disc 25 and thereafter into longitudinal slot 60 in disc 25. The distal end 52 of cable 50 is press fit with crimp nut 61 and the crimp nut 61 is press fit into cylindrical cross-bar 66. Cross-bar is dimensioned to slide to and fro in elongate slot 60 in actuator guide disc 25. Cross-bar 66 has left and right ends 69a and 69b respectively, that extend beyond the respective flat sides of guide disc 25. When jaw assembly 20 is assembled, the left end 69a of cross-bar 66 engages arcuate slot 70a in flat face 33a of left-hand jaw 22a. Similarly, the right end 69b of cross-bar 66 engages arcuate slot 70b in flat face 33b of right-hand jaw 22b.

Trigger 75 is provided within handle 8 to apply axial forces on cable 50 to actuate the jaw elements

between open and closed positions. Referring to FIG. 1, the proximal end 51 of cable 50 along with cable housing 55 extends through bore 17 into the hollow core of plastic handle 8 that is made of mating halves. Trigger 75 rotates around pivot pin 76 to pull cable 50 in the proximal direction. More particularly, the proximal end 51 of cable 50 is fixed in upper arm portion 77 of trigger 75 with crimp nut 79. Cable housing 55 is fixed in molded cable stop 82 within handle 8. Thus, squeezing trigger 75 causes cable 50 to move proximally relative to cable housing 55. Compression spring 85, shown in phantom view in FIG. 1, urges trigger 75 toward the non-depressed (jaw-open) position.

Referring now to FIGS. 3A-3B and 4A-5B, it can be seen that the proximal and distal movement of cable 50 relative to cable housing 55 causes left-hand and right-hand jaw elements 22a and 22b to open and close. FIGS. 3A-3B and 4A-4B are sectional views taken along flat face 33a of left hand jaw element 22a looking away depicting left-hand arcuate slot 70a in plan view. In the aforementioned figures, cooperating elongate slot 60 and arcuate slot 70b of right-hand jaw element 22b are shown in phantom view for explanatory purposes.

In FIG. 3A, spring 85 has urged cable 50 and cross-bar 66 distally relative to the distal end of cable housing 55 that abuts the proximal part of guide disc 25. FIG. 3A shows cross-bar 66 in a distal position in longitudinal slot 60 with left and right ends 69a and 69b of cross-bar 66 having a camming effect as the cross-bar contacts the edges of arcuate slots 70a and 70b. Thus, the camming effect of cross-bar 66 within arcuate slots 70a and 70b causes left-hand and right-hand jaw elements 22a and 22b, and more particularly the hemispherical proximal portions 32a and 32b, to counter-rotate in socket 36. Such counter-

rotation causes jaw arms 42a and 42b to open away from secondary axis 45.

Referring now to FIG. 4A, it can be seen that cable 50 is pulled proximally by trigger 75 and cross-bar 66 has a camming effect as the cross-bar moves proximally in arcuate slots 70a and 70b, thus causing the hemispherical proximal portions 32a and 32b to counter-rotate in socket 36 and thereby further causing jaw arms 42a and 42b to close toward secondary axis 45. The contours and radii of arcuate slots 70a and 70b typically are identical except for being reversed relative to axis 45. It should be noted, however, that the contours and radii of such arcuate slots may vary to provide jaws that move asymmetrically in a variety of manners with respect to secondary axis 45 for special gripping applications.

Of particular interest to the present invention, jaw assembly 20 includes an "open-jaw self-centering" mechanism. By the term self-centering, it is meant that a mechanism is provided to align secondary (jaw) axis 45 with primary axis 15 of introducer sleeve 10 when the jaws are actuated to the open position (see FIG. 3A). This feature is desirable since the jaw elements are in the closed position (see FIG. 4A) for introduction through a cannula. As the jaws are then opened in an endoscopic workspace inside the body, the secondary (jaw) axis 45 preferably is aligned with primary axis 15 for approaching tissue to be gripped. As can be seen in FIG. 3B, the self-centering of the open jaws occurs as jaw elements 22a and 22b are urged by spring 85 to counter-rotate, which counter-rotation is limited as webs 44a and 44b abut the circular periphery of distal aperture 88 of spherical-shaped socket 36. Webs 44a and 44b are symmetrical relative to the corresponding arcuate slots 70a and 70b thus causing secondary axis 45 to align with primary axis 15

when the jaws are in the open position.

Referring now to FIGS. 5A-5B and 6A-6B, it is now possible to describe jaw assembly 20 as it articulates to align itself and secondary axis 45 with the direction of retraction forces. FIG. 5A depicts tissue 90 engaged between working faces 49a and 49b of jaw elements 22a and 22b, respectively, as tissue 90 is being retracted. Since spheroidal-shaped portion 35 of jaw assembly 20 enjoys a slip-type fit in spheroid-shaped socket 36, axis 45 naturally will align itself with the direction of retraction forces. Note that cable 50 and cable housing 55 have sufficient slack in overall length with bore 17 to not interfere with the articulation of jaw assembly 20. FIG. 5B shows the limit of articulation as web 44a abuts the circular periphery of aperture 88.

Of particular interest to the present invention, jaw assembly 20 may rotate in 360° relative to sleeve 10. FIGS. 6A shows jaw assembly 20 articulating at a different angle from that shown in FIG. 5A. FIG. 6B shows the limit of articulation as web 44a abuts the circular periphery of aperture 88 at a different angle. Thus, after gripping tissue 90 within jaw assembly 20, the tissue may be retracted in any direction, or the direction of retraction may be varied, and jaw assembly 20 will articulate and/or rotate allowing axis 45 to remain continuously aligned with the direction of retraction forces.

Also of particular interest to the present invention, jaw assembly 20 includes a "closed-jaw self-centering" mechanism to maintain secondary axis 45 in alignment with primary axis 15 when the jaw elements are in the closed position as shown in FIG. 6A. This feature is desirable, for example, when jaw elements 22a and 22b are actuated to the closed position for introduction through a cannula, in which case it is

desirable to have jaw assembly 20 stabilized rather than free to articulate. The closed-jaw centering mechanism maintains jaw assembly 20 in the "centered" position of FIG. 6A, but such "centered" position can be overcome by a slight force. Referring to FIGS. 7-8, actuator disc 25 is injection-molded of resilient plastic material and formed with spring arms 91a and 91b. The spring arms have tips, 92a and 92b, that extend slightly outward beyond the circular periphery of disc 25. Thus, the tips 92a and 92b abut the wall of sleeve 10 that defines bore 17 adjacent to proximal edge 95 of socket 36 as shown in FIG. 7 to maintain the secondary (jaw) axis 45 in alignment with primary axis 15. As jaw elements 22a and 22b are moved to the open position from the closed position, actuator disc 25 will remain in the "centered" position. When retracting force causes jaw assembly 20 to articulate at any angle in 360° around axis 15, such force will cause either or both tips 92a and 92b of the spring arms to abut the wall of bore 17 adjacent to proximal edge 95 of socket 36 before such force overcomes the spring constant of arms 91a and/or 91b, thus permitting the spring arm(s) to bend and fit within socket 36. FIG. 8 depicts tip 92b of spring arm 91b bending to fit in socket 36 as jaw assembly 20 articulates. Such overcoming forces are preferably slight and depend only on the spring constant formed into spring arms 91a and 91b.

FIG. 9 depicts a second embodiment of gripper 105 with an articulating jaw assembly in which like reference numerals refer to elements common to the previously described first embodiment of FIGS. 1-6B. Gripper 105 differs from the first-described embodiment principally in that it incorporates jaw elements that have a "flex-jaw" feature, by which is meant the jaw elements uniformly apply engaging pressure on tissue

along the length of the jaw working faces.

Referring to FIGS. 9-11, the alternative jaw assembly 120 is similar to the first-described embodiment including left-hand and right-hand jaw elements 122a and 122b, proximal hemispherical portions 132a and 132b, and jaw arms 142a and 142b that are e.g. unitary molded plastic (e.g., Delrin). The jaw arms are connected to proximal hemispherical portions 132a and 132b by rigid webs 144a and 144b respectively. In this embodiment, working faces 149a and 149b are connected to jaw arms 142a and 142b by unitary flexible hinge portions 150a and 150b. The flexibility of hinge portions 150a and 150b is dependent on the cross-sectional dimension and composition of the resilient plastic or other material. FIG. 9 is a sectional view of working faces 149a and 149b in a repose position with gap "G" indicating a limit on flexing the working faces. FIG. 10 depicts jaw working faces 149a and 149b gripping tissue 160 that is thin in cross-section with the working faces pivoting slightly around hinge portions 150a and 150b thus applying engaging pressure over the length of the working faces. As can be seen in FIG. 10, gap "G" is reduced in dimension to accommodate rotation of the working faces. FIG. 11 depicts working faces 149a and 149b gripping tissue 161 that is thick in cross-section with working faces rotated around hinge portions 150a and 150b with gap "G" shown in a corresponding reduced dimension.

Of particular interest to the present invention, left-hand and right-hand jaw elements 122a and 122b may be injection-molded sequentially from a single mold. Referring to FIG. 12, left-hand jaw element 122a with arcuate slot 70a is shown in isometric view. It can be seen that the left-hand jaw element 122a can be flipped over thus providing a right-hand jaw element 122b (not shown) with slot 70a then re-designated as slot 70b.

It should be noted that using a single mold for both left-hand and right-hand jaw elements is best utilized with somewhat smooth jaw working faces, because "alligator-tooth" working faces then will not mesh.

Referring to FIGS. 9 and 13, the second embodiment of gripper 105 offers alternative locations for springs to urge left-hand and right-hand jaw elements 122a and 122b toward the open position. FIG. 9 shows in phantom view an extension spring 165 disposed in longitudinal slot 60. Spring 165 is connected to and pulls cross-bar 66 in the distal direction thus actuating the jaw elements to the open position by means of the camming effect on arcuate slots 70a and 70b as described above. Referring to FIG. 12, trigger 175 pivoting around pivot pin 176 is provided within handle 180 and may additionally apply springing axial forces on cable 450 as described in the first embodiment. Trigger 175 may be urged toward the non-depressed "A" position in plan view in FIG. 13 by extension spring 185 (in phantom view) thus additionally actuating the jaw elements toward the open position.

Referring to FIGS. 10-11, the second embodiment of gripper 105 provides an alternative "self-centering" mechanism to maintain secondary axis 45 in alignment with primary axis 15 in both the open-jaw and closed-jaw positions. The self-centering mechanism comprises conical-shaped helically wound spring 195. The proximal end of spring 197 generally is press fit in bore 17 of sleeve 10 while distal end 198 generally is press fit around the distal end of cable housing 55. As shown in FIG. 11, articulation of jaw assembly 120 tensions spring 195 by lateral movement of distal end 198 and spring 195 will urge the jaw assembly back toward the "centered" position as shown in FIG. 10.

Referring still to FIGS. 9-11, gripper 105 offers a locking mechanism to lock jaw assembly 120 in an

articulated position or a non-articulated position. Such a locking mechanism may be utilized, for example, to lock and rotate tissue while being retracted laterally to better dissect around the tissue. The distal end 12 of sleeve 10 is configured with a distal inclined portion 200 that exhibits a slight increase in cylindrical dimension toward the distal direction. In distal inclined portion 200, the longitudinal slots 38 define longitudinal-extending socket portions 39. A reciprocating sleeve 205 with bore 207 is made of thin-wall metal or plastic and is slidably disposed around introducer sleeve 10.

Referring to FIG. 11, it can be seen that the distal sliding of reciprocating sleeve 205 will press the socket portions radially inward to frictionally grip spheroid-shaped portion 35 of jaw assembly 120. Reciprocating sleeve 205 is actuated proximally or distally by means within handle 180 (see FIG. 13). FIG. 13 shows the proximal end of reciprocating sleeve 205 mounted around introducer sleeve 10. Sleeve 10 is fixed in relationship to handle 180 by elements extending through slots in reciprocating sleeve 205 (not visible). Reciprocating sleeve 205 is urged toward the proximal position by compression spring 215 abutting unitary flange 216 formed into sleeve 205. Trigger 175 actuates reciprocating sleeve 205 distally to lock jaw assembly 120 in any articulated position (see FIG. 11) when upper trigger arm 227 abuts and pushes distally the proximal end 229 of sleeve 205. FIG. 13 shows trigger 175 in plan view in a non-depressed "A" position, with phantom views of trigger 175 in an intermediate "B" position and a fully depressed "C" position. Trigger 175 actuates the jaw elements from the open to closed position as it moves from the "A" position to the "B" position. When trigger 175 is actuated from the "B" position toward

the "C" position, such actuation forces will overcome the strength of compression spring 235 that is disposed around cable 50 and abuts crimp nut 79 within upper trigger arm 227. Thus, it can be seen that after trigger 175 is moved beyond the "B" position toward the "C" position, upper trigger 227 arm will contact proximal end 229 of reciprocating sleeve 205 and push the sleeve distally to lock jaw assembly 120 in any articulated position.

Referring to FIG. 12, it should be appreciated that a jaw element with a "flex-jaw" feature similar to jaw element 220a may be made with a pin-type hinge (not shown) as a pivot point between jaw arm 244a and working face 249a and be within the scope of the present invention. Referring still to FIG. 12, the previously-described actuation mechanism for jaw structures that includes a camming cross-bar 66 and arcuate slots 70a and 70b may be utilized in grippers that do not include an articulating jaw assembly. For example, a gripper may have left-hand and right-hand jaw elements similar to element 122a of FIG. 12 except that the proximal portions of the left-hand and right-hand jaw elements form a cylindrical shape that rotates in cooperating cylindrical-shaped socket.

FIG. 14 illustrates a third embodiment of gripper 305 that incorporates an introducer sleeve 310 extending along primary axis 315 coupled to jaw assembly 320 that closes on secondary axis 325. The secondary axis 325 may articulate relative to primary axis 315. In this embodiment, the flexible connection between sleeve 310 and jaw assembly 320 is a flexible universal joint 330 made of any suitable resilient material such as urethane. In FIG. 14, it can be seen that jaw elements 333a and 333b rotate around pin 334. The jaw elements are urged to the open position by torsion spring 335 shown in phantom view. Flexible

braided steel cables 340a and 340b are disposed in cable housing 344 for actuating the jaws to the closed position. The distal end of cable housing 344 abuts the proximal end of universal joint 330 and cable 340a and 340b extend through bore 350 in the universal joint. Thus, it can be seen that proximal movement of cables 340a and 340b relative to cable housing 344 will actuate jaw elements 333a and 333b to the closed position.

Still referring to FIG. 14, it can be seen in phantom view that universal joint 330 may flex. When gripper 305 is utilized to retract tissue 360 laterally relative to primary axis 315, the universal joint will articulate allowing secondary axis 325 of jaw assembly 320 to align itself with the direction of retraction forces. It should be appreciated that gripper 305 may be fitted with a metal universal-type joint (not shown) of the type that has multiple pivots and be within the scope of the present invention. It should be further appreciated that gripper 305 may be fitted with a universal-type joint (not shown) of the type that has a helically-wound spring connecting proximal and distal portions of an introducer sleeve thus providing flexibility and be within the scope of the present invention.

Of particular interest to the present invention, referring to FIG. 14, thin-wall reciprocating sleeve 365 may be slidably mounted around introducer sleeve 310. When reciprocating sleeve 365 is slid distally to extend over universal joint 330 and maintained in such a position as shown in phantom view, the flexibility of universal joint 330 will be disabled. Thus, a single gripper 305 is provided that selectively offers either a rigid-axis jaw assembly or an articulating-axis jaw assembly. Further, it should be appreciated that reciprocating sleeve 365 may have a distal rest

position thereby disabling universal joint 330 and the sleeve 365 may be actuatable in the proximal direction by the trigger mechanism (not shown) that actuates jaw elements 333a and 333b toward the closed position. Thus, universal joint 330 may be disabled while said jaws move from the open position toward the closed position until a certain degree of closure is reached, after which universal joint 330 is free to articulate as sleeve 365 moves proximally.

2. <u>Traction Jaws Instrument</u>

By way of example, FIG. 15 depicts a traction jaws instrument 405 with plastic handle assembly 407 including proximal handle member 408 and distal handle member 409. Distal handle member 409 is fixed to elongate inner sleeve 410 by adhesives or other suitable means. Inner sleeve 410 with proximal and distal ends 411 and 412, has a cylindrical shape extending along axis 415 with "throat" or bore 417. Sleeve 410 is made of a somewhat flexible plastic such as Delrin®.

Outer sleeve 420 with proximal and distal ends respectively 421 and 422, has a cylindrical shape and defines bore 425 and is slidably disposed around inner sleeve 410. Outer sleeve 420 is made of any suitable material such as thin-wall metal or plastic and has an outer diameter of approximately 10 mm. (not limiting) to cooperate with a standard 10-11 mm. inside diameter cannula.

Still referring to FIG. 15, jaw assembly 430 is incorporated into the distal end 412 of sleeve 410 and includes first and second opposing jaw structures in which each jaw structure is double-pivoting. By double-pivoting it is meant each jaw structure includes a pivotable distal jaw working arm and a pivotable proximal forearm. Referring to FIG. 16, distal jaw

working arms 432a and 432b pivot around pins 433a and 433b, respectively. Jaw working arms 432a and 432b are made of any suitable material such as injection-molded plastic and extend along axes 435a and 435b, respectively. As seen in FIG. 16, proximal forearms 442a and 442b are molded portions of the injection-molded inner sleeve 410 and pivot around resilient hinge portions 443a and 443b, although pin-type hinges are within the scope of the invention. Forearms 442a and 442b extend along axes 444a and 444b respectively (see FIGS 17-19).

The double pivoting of each jaw structure is provided to align jaw working arms 432a and 432b generally parallel with one another as tissue is engaged to evenly distribute pressure over tissue, no matter the thickness of tissue as shown in FIGS. 18-19. The even distribution of engaging pressure is to be contrasted with single pivot jaw structures in which the proximal portion of a jaw closes on tissue before the distal portion of the jaw.

Rolling tracks 445a and 445b are formed in a loop and are made of flexible material such as polyurethane and may be similar to the composite construction of 3 mm. to 6 mm. wide Flex-E-Grip® belts available from W.M. Berg, Inc. of East Rockaway, New York. Rolling tracks 445a and 445b are impressed with tissue-gripping serrations 449 molded into the tracks' surfaces. Tracks 445a and 445b are dimensioned in width to fit within bore 417 of inner sleeve 410 and to roll around distalmost rollers 450a and 450b of jaw working arms 432a and 432b. The loops of track 445a and 445b also roll around proximal rollers 452a and 452b within handle 407 (see FIG. 6). A drive mechanism for rolling the tracks 445a and 445b is described in detail below.

A jaw-actuating mechanism is provided to rotate jaw working arms 432a and 432b around their respective

pivots, 433a and 433b. The jaw-actuating mechanism also rotates jaw forearms 442a and 442b around their respective pivots 443a and 443b. Referring to FIGS. 16-19, jaw-actuation is provided by the reciprocation of outer sleeve 420 over inner sleeve 410. Referring to FIG. 17, the jaw working arms 432a and 432b, are urged to an open "A" position by torsion springs 455a and 455b. The "A" position of FIG. 17 refers to the maximum angle "A" between instrument axis 415 and jaw working axes 435a and 435b which is approximately 40° (not limiting).

Referring to FIG. 18, the distal sliding of outer sleeve 420 over inner sleeve 410 causes sleeve distal end 422 to contact cam surfaces 457a and 457b of jaw working ends 432a and 432b and to rotate the jaw working ends around their respective pivots, 433a and 433b, to achieve an intermediate closed "B" position. The "B" position of FIG. 18 refers to angle "B" between instrument axis 415 and jaw working axes 435a and 435b which then is 0° or parallel. FIG. 19 illustrates that further distal sliding of outer sleeve 420 causes its distal end 422 to force cam surfaces 457a and 457b inward toward axis 415 as jaw forearms 442a and 442b rotate around their respective hinge portions 443a and 443b, to a fully closed "C" position. The "C" position of FIG. 19 refers to the maximum angle "C" between axis 415 and jaw forearm axes 444a and 444b which is approximately 5° to 10° (not limiting).

The jaw-actuating mechanism, and more particularly the reciprocation of the outer sleeve 420, is operable from handle 407 as shown in FIGS. 15 and 20. Plastic thumb grip 460 is fixed by any suitable means such as adhesives to proximal end 421 of outer sleeve 420. Thumb grip 460 and sleeve 420 are releasably maintainable in any axial position by annular ribs 464 within counterbore 465 in thumb grip 460 that engage

cooperating annular indents 466 in the distal reduced-diameter portion 467 of handle member 409 (see FIG. 21). To slide thumb grip 460 over reduced-diameter portion 467, the thumb grip is made of resilient plastic such as Delrin® and a plurality of flexing slots 469 (see FIG. 15) allows proximally-extending portions 470 of the thumb grip to flex radially outward slightly as it is slid to and from over indents 466 (see FIG. 21) of handle member 409.

A drive mechanism is provided to roll the tracks 445a and 445b around distal rollers 450a and 450b, and proximal rollers 452a and 452b. Referring to FIGS. 20-21, the drive mechanism includes bow member 472 with six (not limiting) flexible bows 475a-475f. The flexible bows 475a-475f are portions of a unitary injection-molded resilient plastic bow member 472 in which the intermediate portions 476 of each bow have a uniform thickness to provide uniform bending. The bows have proximal hinge portions 477a-477f, and distal hinge portions 479a-479f, that are reduced in sectional dimension to induce bending at the hinge portion (see FIG. 20). It should be appreciated that bows with pin-type hinges are within the scope of the present invention. The proximal tube portion 480 of bow member 472 is fixed to proximal handle 408. The distal tube portion 482 of bow member 472 is fixed to proximal handle 409. In the sequence of FIGS. 20-21, it can be seen that squeezing any opposing bows 475a-475f, inward toward axis 415 will cause proximal handle member 408 to separate from distal handle member 409. The travel of proximal handle 408 causes drive member 483 to transmit force to tracks 445a and 445b as further described below. A drive mechanism utilizing a plurality of flexible bows allows the surgeon to rotate the handle 360° within one hand to align the jaws with tissue and thereafter to actuate the instrument by a

squeezing motion no matter how the instrument is rotated. A squeeze-actuated driv mechanism is to be contrasted with a pistol grip which may require awkward wrist movements to both rotate and actuate the instrument.

The flexible bows 475a-475f are urged to the expanded position of FIG. 20 by compression spring 485 that is disposed around inner sleeve 410 and within bore 486 in telescoping sleeve 488. Referring to FIG. 21, it can be seen that spring 485 exerts pressure on flange 489 of sleeve 410 and flange 490 of telescoping sleeve 488.

Referring to FIGS. 20 and 24, the manner in which the drive mechanism engages tracks 445a and 445b is illustrated. Drive member 483 is made of resilient plastic such as Delrin® that includes resilient spring legs 491a and 491b that are adapted to engage serrations 449 impressed into tracks 445a and 445b (see FIG. 24). As bow member 472 is squeezed causing drive member 483 to travel proximally, spring legs 491a and 491b are in a repose state and engage serrations 449 thereby causing tracks 445a and 445b to roll. As inward pressure on bow member 472 is relaxed, spring 485 moves causes drive member 483 to travel distally and spring legs 491a and 491b bend around hinge portions 493a and 493b respectively to flattened configuration and slide over serrations 449. Drive member 483 may be moved proximally so that spring legs 491a and 491b are proximal from proximal rollers 452a and 452b (see FIG. 24) and out of engagement with the rolling tracks thus permitting the tracks to roll freely to release grip on tissue.

Inner sleeve 410 and outer sleeve 420 of the instrument may be fabricated of transparent medical grade plastic to view the quantity of tissue retracted into bore 417. Jaw arms 432a and 432b and the rolling

tracks also maybe made of clear plastic. The sides of outer sleeve 420 may have slotted sides (not shown) to cooperate with the space between jaw forearms 442a and 442b (see FIG. 16).

Operation and use of the instrument of FIG. 15 in performing a method in accordance with the present invention can be described briefly as follows with reference to FIGS. 18-19. Preliminarily, the surgeon grasps the instrument in one hand and with his thumb slides thumb grip 460 distally to the "C" position to close jaw working ends 432a and 432b in order to permit the instrument to be introduced through a cannula into an endoscopic workspace. Under conventional endoscopic vision, the surgeon slides thumb grip 460 to the "A" position to open jaw assembly 430. The surgeon then advances jaw working ends 432a and 432b toward tissue to be engaged then slides thumb grip 460 distally to close jaw working ends 432a and 432b on opposing sides of the tissue. The surgeon then may successively apply and release inwardly-directed force on opposing bows 475a-475f thereby causing tissue to be gripped by tracks 445a and 445b and progressively drawn into the "throat" or bore 417 or inner sleeve 410. At any time, the surgeon may re-adjust the closure of the jaw working ends 432a and 432b to suitably grip tissue 499 by sliding thumb grip 460 either proximally or distally.

FIGS. 25-26 illustrate a second embodiment of a gripping instrument 505 in which like reference numbers refer to elements common to the first-described instrument 405. Instrument 505 differs only in the use of a secondary flexing bow drive mechanism for actuating the instrument's jaw structure. This variation of a flexing bow drive includes a locking mechanism. Also the resilient material of the flexing bows has a spring constant to urge the drive mechanism

toward the expanded position from the contracted position.

Referring to FIG. 25, distal proximal handle portion 508 of inner sleeve 510 carries secondary bow member 572. The flexible bows 575a-575f are portions of a unitary injection-molded resilient plastic bow member 572 in which the intermediate portions 576 each serve as a leaf-type spring and urge each bow to the expanded position of FIG. 25. The bows have proximal hinge portions 577a-577f, and distal hinge portions 579a-579f, that are reduced in sectional dimension to allow pivoting at the hinge portion (see FIG. 25). The proximal tube portion 580 of bow member 572 is fixed distal handle portion 508 of sleeve 510. The distal tube portion 582 of bow member 572 is fixed to outer sleeve 520. In the sequence of FIGS. 25-26, it can be seen that squeezing any opposing bows 575a-575f, inward toward axis 415 will cause outer sleeve 520 to move distally relative to distal handle portion 508 and sleeve 510 to actuate jaw structure 430.

It should be noted that flexible bows 575a-575f may be made of a spring-type metal with a spring constant incorporated in each such bow. Such metal bows would include a pin-type proximal and distal hinges for pivoting.

Referring to FIGS. 25-26, proximal handle member 408 includes a mechanism for releasably locking bow member 572 in any actuated position between the expanded and contracted positions. Distal tube portion 582 of bow member 572 includes opposing resilient latch arms 580a and 580b, with teeth 584a and 584b that engage one of the annular indents 585 in distal handle portion 508 of sleeve 510. The proximalmost ends of latch arms 580a and 580b may be depressed to pivot around respective resilient pivots 587a and 587b, to lift teeth 584a and 584b out of engagement with annular

indents 585 and thus allow the spring constant of flexible bows 575a-575f to return bow member 572 to the expanded position.

FIG. 27 depicts a second embodiment of retraction instrument 605 having a single rolling track. Instrument 605 includes plastic handle assembly 607 coupled to inner sleeve 610 that has proximal and distal ends 611 and 612, and extends along axis 615. Sleeve 610 with longitudinal bore 617 is made of any suitable material such as plastic or metal. The proximal end 611 of sleeve 610 is fixed in counterbore 619 of handle 607. Outer sleeve 620 with proximal and distal ends 621 and 622, has a cylindrical shape with bore 625 and is slidably disposed around inner sleeve 610. Outer sleeve 620 has an outside diameter of approximately 10 mm. (not limiting) to cooperate with a standard 10-11 mm. cannula.

Still referring to FIG. 27, track arm 632 is pivotably coupled to distal end 612 of sleeve 610 and rotates around pin 633. Rolling track 645 with serrations 649 is similar the first-described embodiment and rolls around distal roller 650 and proximal roller 652 in handle 607.

An arm-actuating mechanism is provided to articulate track arm 632 around pivot pin 633 to align track arm axis 655 generally parallel to tissue. Referring to FIG. 27, track arm 632 is urged toward the articulated "X" position by torsion spring 656. Track arm 432 may be articulated to the straight "Y" position shown in phantom view by the reciprocation of outer sleeve 620 relative to inner sleeve 610. As sleeve 620 slides in the distal direction over inner sleeve 610, distal end 622 of sleeve 620 abuts cam surface 657 of track arm 632 causing the track arm to pivot around pin 633. Sleeve 620 is slid to and fro over inner sleeve 620 by lever grip 660 rotating around pivot 662 in

handle 607. Grip 660 and more particularly its upper lever arm portion 665 is flexibly coupled to proximally-extending tongue 666 that extends from proximal end 611 of plastic outer sleeve 620. The flexible coupling between arm portion 665 and tongue 666 may be any suitable connection and is shown as a ball and socket-type joint 668 that snap-fits together. Sleeve 620 is maintained in any reciprocated position between the "X" and "Y" positions by sharp edge 669 that springably engages cooperating indents 670 that are molded into plastic handle 607. Spring gap 672 in tongue 666 allows resilient plastic edge 669 to flex inwardly toward axis 615 to move between indents 670. Thus, it can be seen that the rotation of lever grip 660 will articulate track arm 432 between the "X" and "Y" positions.

A drive mechanism is provided to roll track 645 around proximal and distal rollers respectively 650 and 652. The drive mechanism includes plastic trigger 675 made of a resilient plastic such as Delrin® that is slidably disposed in slot 677 molded into handle 607. Compression spring 679 urges trigger 675 to its distalmost position. Slanted resilient plastic spring legs 680 are molded into trigger 675 and are adapted to engage serrations 646 in track 645 as the trigger is depressed (proximally) thus causing the track to roll in a clockwise direction as seen in FIG. 27. As trigger 675 is released and is urged distally by compression spring 679, the resilient ratchet legs 680 flex away from axis 615 and slide over serrations 646 in track 645. A mechanism is provided to prevent track 645 from rolling counter-clockwise in the view of FIG. 27 and includes resilient plastic cog 685 molded into handle 607. Cog 685 flexes outwardly as serrations 646 pass underneath it when the track rolls in a clockwise direction as seen in FIG. 27 and thereafter cog 685

will flex inwardly to engage serrations 649 to prevent track 445 from rolling counter-clockwise as trigger 465 is released.

Operation and use of the instrument of FIG. 27 in performing a method in accordance with the present invention can be described briefly as follows. The surgeon moves lever grip 660 to the "Y" position thereby causing the axis 655 of track arm 632 to be aligned with instrument axis 615. The surgeon then may introduce the straightened instrument through a cannula into the endoscopic workspace. Under endoscopic vision, the surgeon may move lever grip 660 to articulate track arm 632 to make it generally parallel to tissue 699 as he presses track 645 gently into tissue. Thereafter, the surgeon sequentially depresses and releases trigger 675 causing track 645 to roll thereby progressively applying intracorporeal traction on tissue without any axial movement of the instrument.

This disclosure is illustrative and not limiting. Other variations will be apparent as for example an instrument having short rolling tracks that roll only around the jaw working ends together with an elongate flexible drive member that extends through the instrument to engage the tracks. Other mechanisms will be apparent for rolling the tracks such as mechanical means for rotating the rollers that engage the tracks. Also, the jaws may be actuated by conventional extension members that are connected to a lever arm on each jaw. Also, the distal end of the instrument's introducer sleeve may have a flexible universal joint as disclosed above. Further variations will be apparent to one skilled in the art in light of this disclosure and are intended to fall within the scope of the appended claims.

I claim:

1. A surgical instrument for engaging tissue comprising:

an elongate introducer member defining a longitudinal first axis;

two opposing jaw structures each coupled to a distal end of said introducer member, each said jaw structure having a working face adapted to engage tissue, said jaw structures each being moveable between a closed position wherein said working faces converge toward a second axis defined by said two jaw structures and an open position wherein said working faces separate away from said second axis, said second axis being independent of said first axis;

a jaw actuating structure operatively connected to said jaw structures, thereby causing said working faces to move between the open and closed positions; and

an articulating structure connecting said introducer member to said jaw structures, thereby allowing said jaw structures to articulate together relative to said first axis.

2. The instrument of Claim 1, wherein said jaw structures articulate in response to directional retraction forces from the engaged tissue, wherein said jaw structures articulate between being parallel and non-parallel to said first axis.

3. The instrument of Claim 1, wherein said actuating structure further allows said jaw structures to rotate relative to said first axis.

4. The instrument of Claim 1, wherein said

articulating structure comprises a ball and socket joint.

5. The instrument of Claim 1, wherein said articulating structure comprises a universally flexible joint made at least partly of a resilient material.

6. The instrument of Claim 1, wherein said articulating structure comprises a universal joint including a plurality of substantially rigid elements pivotably connected with one another.

7. The instrument of Claim 1, wherein said articulating structure comprises a universal joint including a helically wound spring.

8. The instrument of Claim 1, further comprising a self-aligning mechanism operatively connected to said jaw structures, thereby maintaining said second axis as defined by said jaw structures in substantial alignment with said first axis when said jaw structures are in the open position.

9. The instrument of Claim 8, wherein said articulating structure comprises a ball and socket joint, and said self-aligning mechanism comprises portions of said jaw structures symmetrically abutting an edge of an aperture in the socket of said ball and socket joint.

10. The instrument of Claim 8, wherein said articulating structure comprises a ball and socket joint and said self-aligning mechanism comprises at least one spring disposed within said introducer member that urges said second axis, as defined by said jaw structures, into alignment with said first axis.

11. The instrument of Claim 1, further comprising a jaw self-aligning mechanism operatively connected to said jaw structures, thereby releasably maintaining said jaw structures in substantial alignment with said first axis when said jaw structures are moved toward the closed position from the open position.

12. The instrument of Claim 11, wherein said articulating structure comprises a ball and socket joint and said self-aligning mechanism comprises a plurality of spring elements incorporated into proximal portions of said jaw structures that releasably engage an edge portion of said socket.

13. The instrument of Claim 1, including a locking mechanism operatively connected to said jaw structures, thereby releasably locking said articulating structure in any articulated or non-articulated position.

14. The instrument of Claim 13, wherein said articulating structure includes a cooperating ball element and socket element joint.

15. The instrument of Claim 14, wherein said locking mechanism comprises means for reducing an internal dimension of the socket element to frictionally engage said ball element.

16. The instrument of Claim 1, further comprising a locking mechanism operatively connected to said jaw structures, thereby releasably maintaining said jaw structures along said second axis in alignment with said first axis.

17. The instrument of Claim 1, wherein said

articulating structure comprises a universal-type joint and said locking mechanism comprises a reciprocating sleeve slidably mounted around said introducer member, wherein a slidable disposition of said reciprocating sleeve over said universal-type joint locks said universal-type joint.

18. The instrument of Claim 1, each said jaw structure further including a hinge located intermediate its distal end and said articulating structure, thereby allowing each jaw structure to further articulate at said hinge.

19. A surgical instrument for engaging tissue comprising:

an elongate introducer member;

opposing first and second jaw structures each having a proximal portion, and having respective first and second distal working ends, wherein said first and second jaw structures each rotate around a primary pivot associated with a distal end of said introducer member, said first and second distal working ends being pivotably connected respectively to said first and second jaw structures around an associated secondary pivot; and

a jaw actuating structure operatively connected to said first and second jaw structures, said jaw structures thereby each rotating around said associated primary pivot, said jaw actuating structure thereby causing said first and second distal working ends to separate from one another and converge toward one another, said first and second distal working ends each being rotatable around the associated secondary pivot.

20. The instrument of Claim 19, wherein said distal working ends separate and converge as tissue is engaged, and wherein said distal working ends apply pressure on the tissue over a length of each said distal working end.

21. The instrument of Claim 19 wherein each said secondary pivot is a unitary resilient hinge.

22. The instrument of Claim 19 wherein said secondary pivot is a pin-type hinge.

23. The instrument of Claim 19 wherein said primary pivot is located proximal from said secondary pivot for rotating the jaw working ends.

24. The instrument of Claim 23, wherein said secondary pivot is adapted for maintaining said distal working ends in a generally parallel relationship when the engaging tissue.

25. A method of operating a surgical instrument to engage tissue, said surgical instrument having two opposing jaw structures, comprising the steps of:

engaging the tissue by closing said two jaw structures together along a first axis thereby to engage the tissue therebetween;

retracting the engaged tissue along a second axis independent of said first axis with said surgical instrument; and

articulating said two jaw structures along said second axis as the engaged tissue is retracted.

26. The method of Claim 25, further comprising the step of rotating each of said jaw structures around

a pivot point.

27. A surgical instrument for engaging tissue, comprising:

an elongate member defining a longitudinal axis;

two opposing jaw structures both being movable between an open and a closed position, each said jaw structure having an opposing working face adapted to engaging tissue, and

a pivotal coupling connecting each of said jaw structures to an end of said elongate member, wherein said jaw structures each conjointly pivot relative to said longitudinal axis at least when in said closed position.

28. A surgical instrument for applying traction on tissue, comprising:

an elongate introducer member;

at least one rolling track for engaging tissue incorporated into a distal end of said introducer member; and

a track drive mechanism operatively connected to said rolling track.

29. The instrument of Claim 28, wherein said rolling track has serrations on its surface.

30. The instrument of Claim 29, wherein said track drive mechanism comprises a drive member reciprocating along a longitudinal axis defined by said introducer member and at least one cooperating flexible member engaging said serrations on the surface of said rolling track, thereby rolling said rolling track.

31. The instrument of Claim 29, wherein said

rolling track is flexible.

32. A surgical instrument for applying traction on tissue, comprising:

an elongate introducer member;

an arm structure having at least a first arm working end associated with a distal end of said introducer member;

a rolling track adapted to engage tissue and incorporated into said first arm working end; and

a track drive mechanism operatively connected to said rolling track.

33. The instrument of Claim 32, wherein said arm structure includes:

a first pivot associated with said distal end of said introducer member around which said first arm working and rotates; and

an arm structure actuating mechanism thereby causing said first arm working end to rotate around said first pivot.

34. The instrument of Claim 32, wherein said track drive mechanism includes a reciprocating drive member having a resilient portion that engages cooperating indentations in said rolling track.

35. The instrument of Claim 34, wherein said track drive mechanism further comprises:

a plurality of longitudinally-extending flexible bow elements each moveable between a first position wherein said bow elements are flexed outward away from said axis and a second position wherein said bow elements are flexed inward toward said axis, said flexible bow elements being connected to said reciprocating

drive member whereby movement between said first and second positions causes proximal and distal travel along a longitudinal axis defined by said introducer member of said reciprocating drive member.

36. The instrument of Claim 35, wherein said plurality of bow elements define a structure having symmetry in 360° relative to a longitudinal axis of said introducer member.

37. The instrument of Claim 32, further comprising an arm structure locking mechanism operatively connected to said arm structure, thereby locking said first arm working end in any rotated position.

38. The instrument of Claim 32,

said arm structure further comprising a second arm working end opposing said first arm working end, said second arm working end rotating around a second pivot associated with said distal end of said introducer member; and

an arm-actuating mechanism rotating both said first and second arm working ends on their respective first and second pivots thereby to move said first and second arm working ends towards and away one another.

39. The instrument of Claim 38, further comprising a rolling track adapted to engage tissue incorporated into said second arm working end.

40. The instrument of Claim 39, further comprising a track drive mechanism operatively connected to each said rolling track.

41. The instrument of Claim 40,

wherein said arm structure includes a first proximal arm portion and a second proximal arm portion connected respectively to said first arm working end and said second arm working end, and

a third pivot and a fourth pivot respectively connecting said first and second proximal arm portions to said distal end of said introducer member.

42. A surgical instrument comprising:

an elongate introducer member;

an arm structure coupled to a distal end of said introducer member, said arm structure including:

first and second cooperating jaw elements each having a proximal forearm and a distal working end, each forearm rotating around a primary pivot coupled to said distal end of said introducer member, each working end being pivotably connected to a respective forearm by a secondary pivot;

a working end-actuation mechanism coupled to each working end, thereby causing each working end to separate from and converge toward one another around its secondary pivot; and

a forearm-actuation mechanism coupled to each forearm, thereby causing each working end to separate from and converge toward one another around its secondary pivot.

43. The instrument of Claim 42, further comprising a rolling track coupled to each working end.

44. The instrument of Claim 42, further

comprising a track drive mechanism operatively connected to each rolling track.

45. The instrument of Claim 42, further comprising an arm structure locking mechanism operatively connected to said arm structure, thereby locking said arm structure in any one of a plurality of rotated positions relative to the pivots.

46. The instrument of Claim 42, wherein said introducer member is at least partly of transparent material.

47. A surgical instrument that engages tissue, comprising:

an extension member;

a jaw structure with first and second jaws respectively having first and second proximal portions and first and second distal working ends, and each proximal portion rotating around an associated primary pivot associated with a distal end of said extension member, each working end being pivotably connected to the associated proximal portion by a secondary pivot;

a working end-actuation mechanism operatively connected to said first and second working ends thereby to rotate said first and second working ends around said secondary pivots, thereby causing said first and second working ends to separate from and converge toward one another; and

a proximal portion-actuation mechanism operatively connected to said first and second jaws thereby to rotate said first and second jaws around said primary pivots and thereby causing said first and second working ends to further separate from and converge toward one another.

48. The instrument of Claim 47, wherein each said secondary pivot is a unitary resilient hinge.

49. The instrument of Claim 47, wherein each said secondary pivot is a pin-type hinge.

50. A drive system for a surgical instrument for transmitting force to an actuatable working structure of the surgical instrument, comprising:

an extension member defining an axis;

a drive member operatively connectable to said working structure;

a drive mechanism connected to said drive member and associated with said extension member, said drive mechanism comprising a plurality of longitudinally-extending flexible bow elements operatively connected to said drive member and each bow element being moveable between a first position wherein said bow elements are flexed outward away from said axis, and a second position wherein said bow elements are flexed inward toward said axis, whereby movement between said first and second positions causes proximal and distal axial travel of said drive member transmitting force from said drive mechanism to said working structure.

51. The instrument of Claim 50, wherein said flexible bow elements are urged toward the first position from the second position by a spring force within said flexible bow elements.

52. The instrument of Claim 50 wherein said flexible box elements are urged toward the first position from the second position by a spring associated with said extension member.

53. The instrument of Claim 50, further comprising a drive mechanism lock operatively connected to said drive mechanism, thereby locking said drive mechanism in any one of a plurality of positions between said first and second positions.

54. A method of applying traction to tissue in an endoscopic workspace, comprising:

introducing a distal end of an introducer that incorporates a rolling track adapted for engaging tissue into said workspace proximate to said anatomic tissue;

pressing said rolling track against said tissue to engage said tissue; and

rolling said rolling track, thereby applying traction on said tissue.

55. A method of applying traction on tissue in an endoscopic workspace, comprising:

introducing a distal end of an introducer into said workspace proximate to said anatomic tissue, wherein said distal end includes first and second pivotable opposing jaws each having a rolling track;

closing said opposing pivotable jaws around said tissue; and

rolling said rolling tracks, thereby applying traction on opposing sides of said tissue.

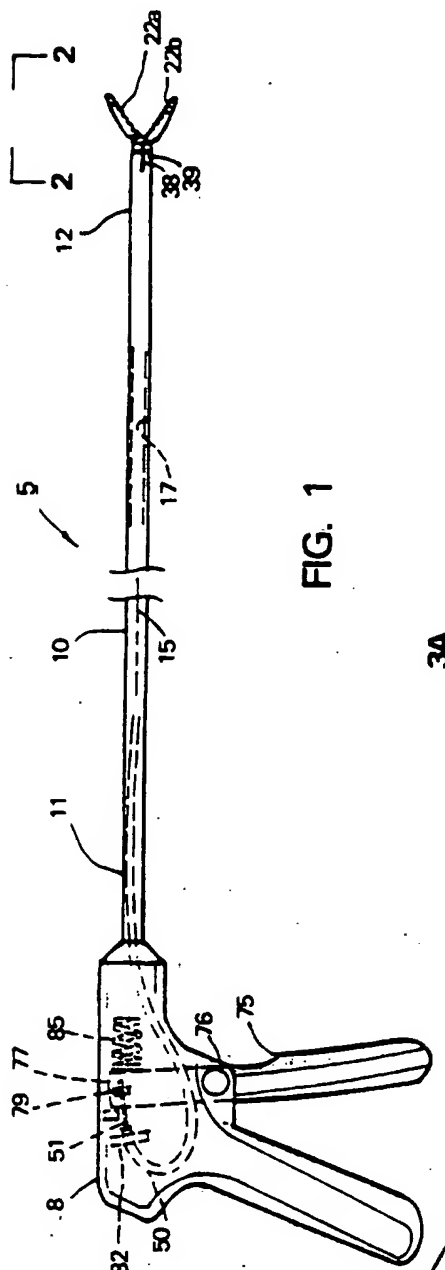
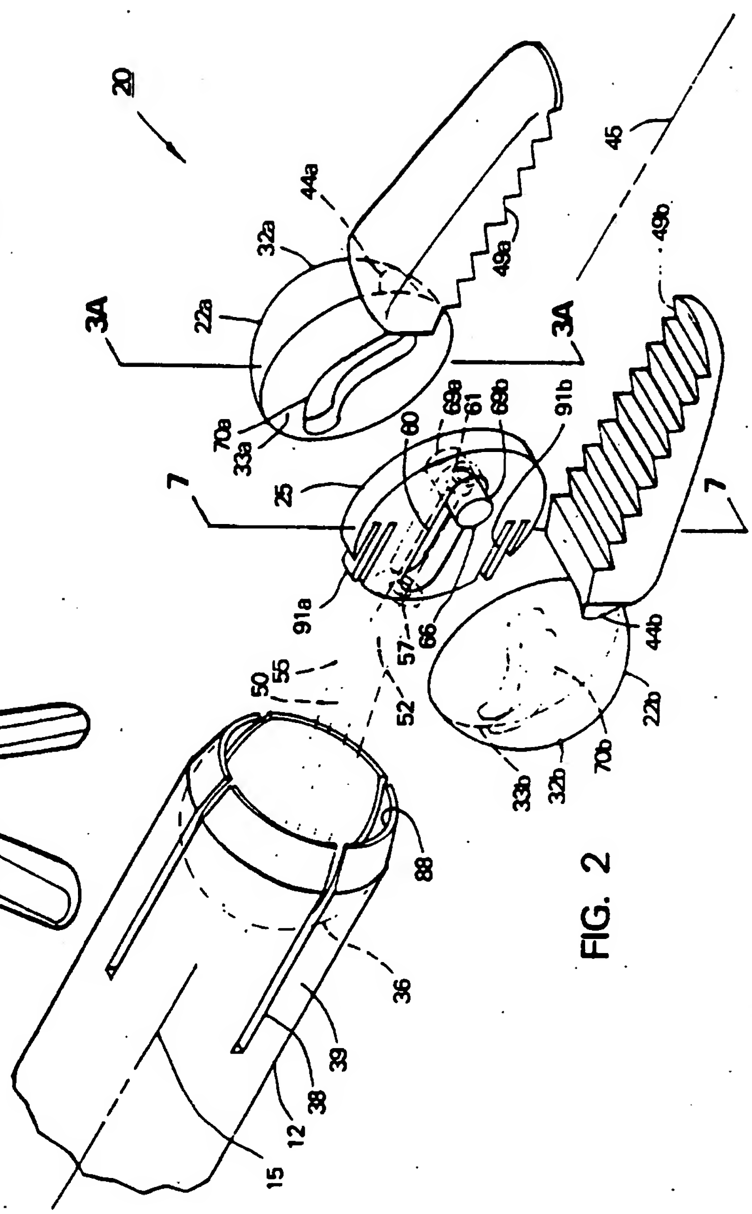

2
2
22a
22b
38
39
12
5
17
10
15
11
85
75
76
77
79
51
8
82
50

FIG. 1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22a
3A
3A
49a
49b
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70a
33a
69a
61
69b
60
91b
25
7
7
91a
57
66
44b
50
55
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22b
70b
32b
33b
88
36
39
38
12
15

FIG. 2

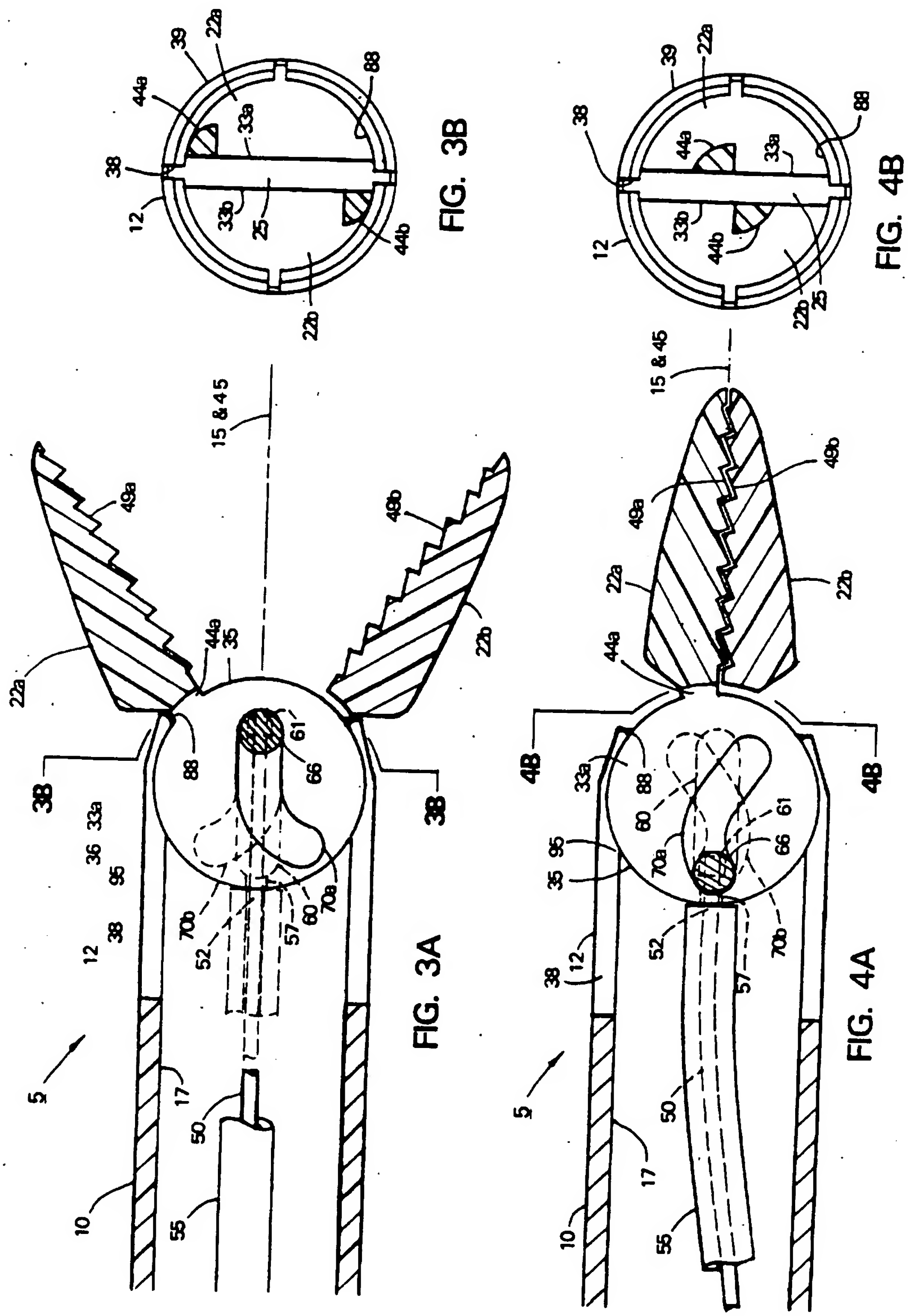



FIG. 3B

FIG. 4B

FIG. 3A

FIG. 4A

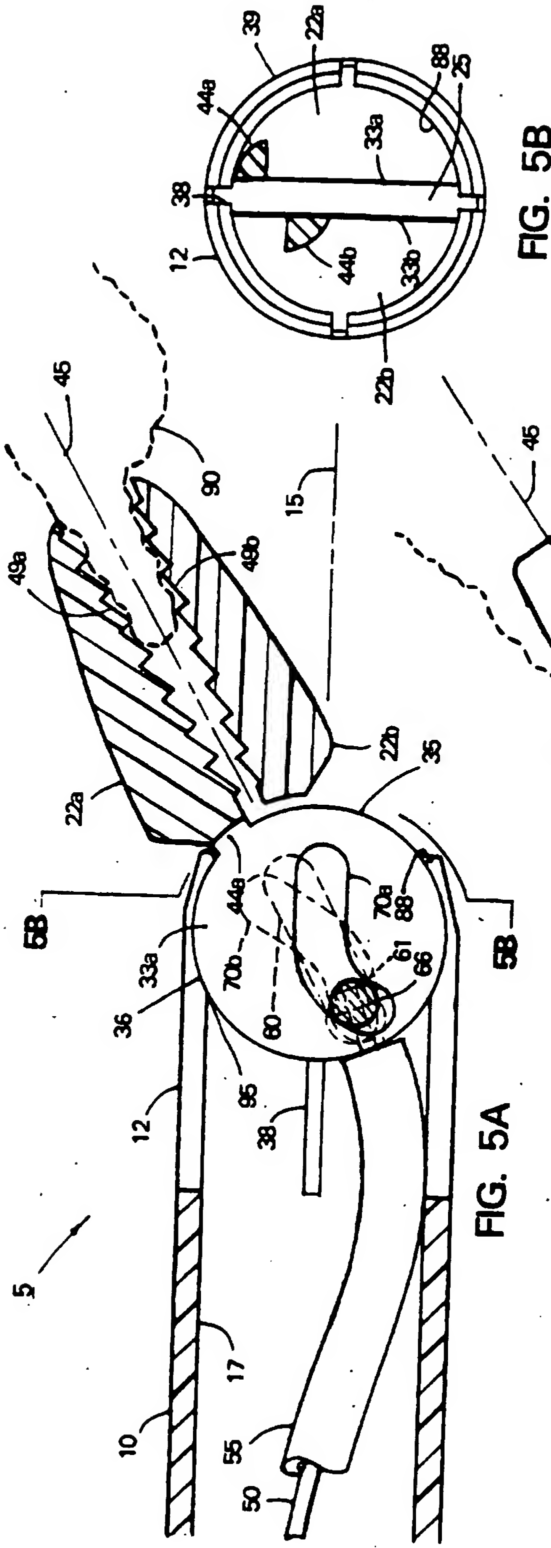


FIG. 5A

FIG. 5B

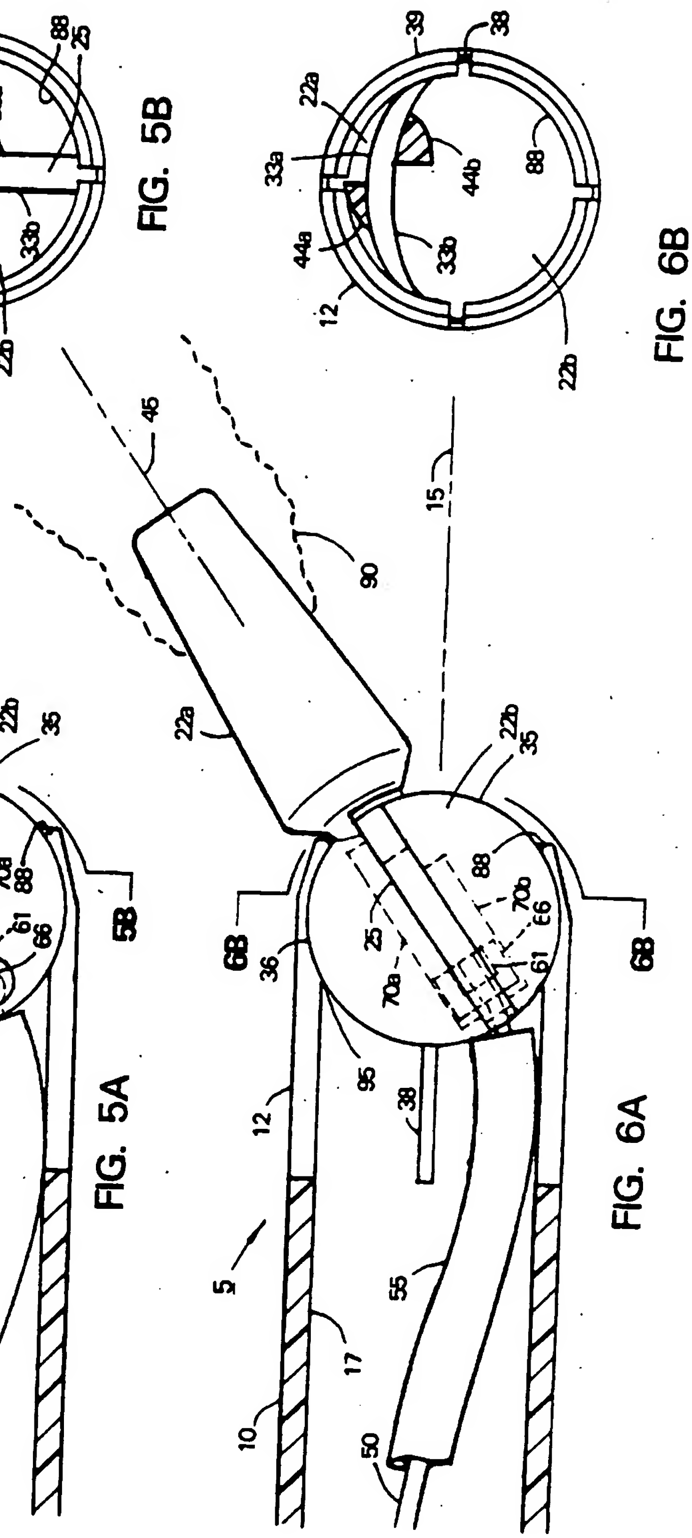
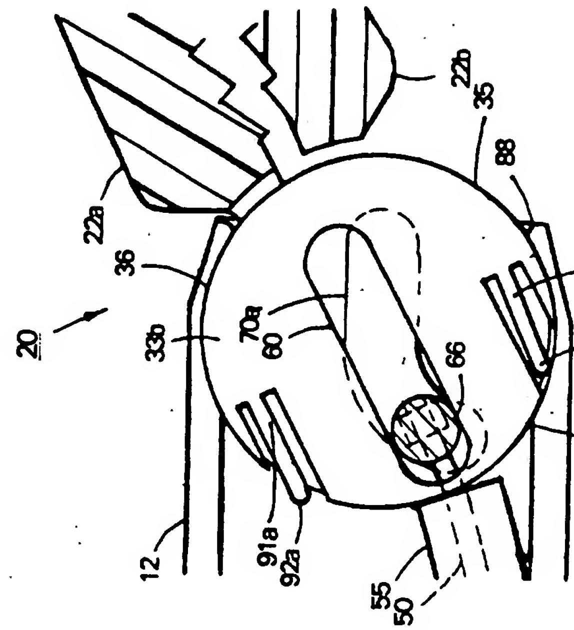


FIG. 6A

FIG. 6B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91a
92a
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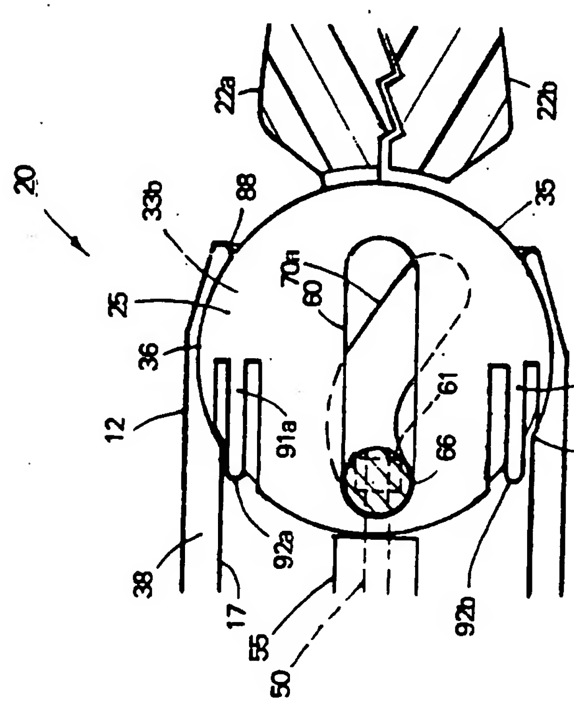
FIG. 8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61
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91a
91b
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38
17
92a
92b
55
50

FIG. 7

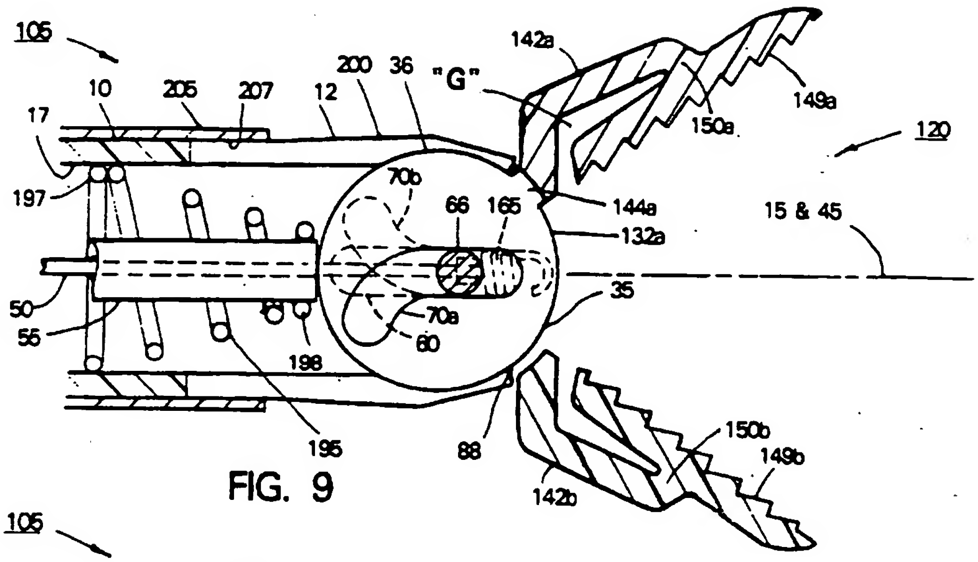



FIG. 9

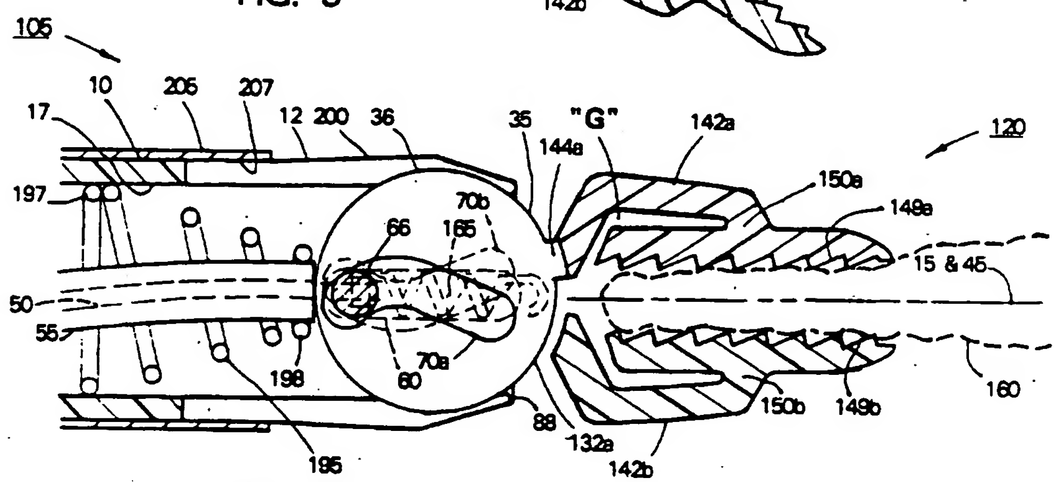



FIG. 10

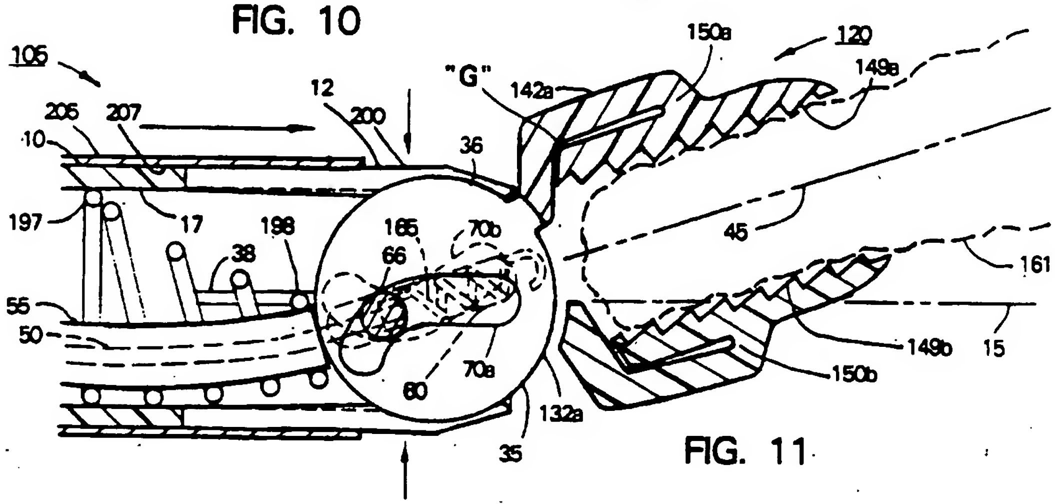
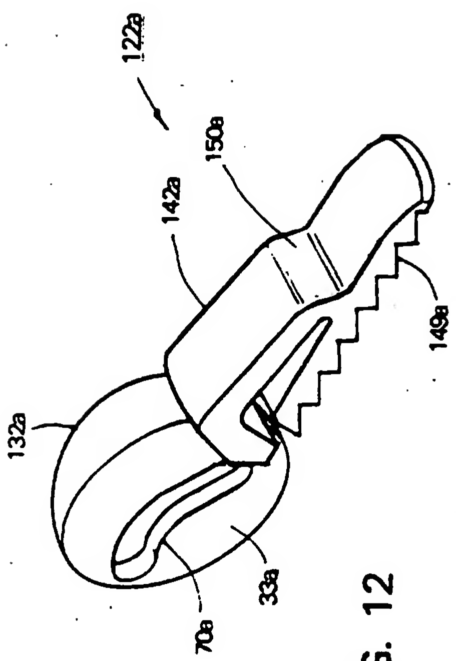



FIG. 11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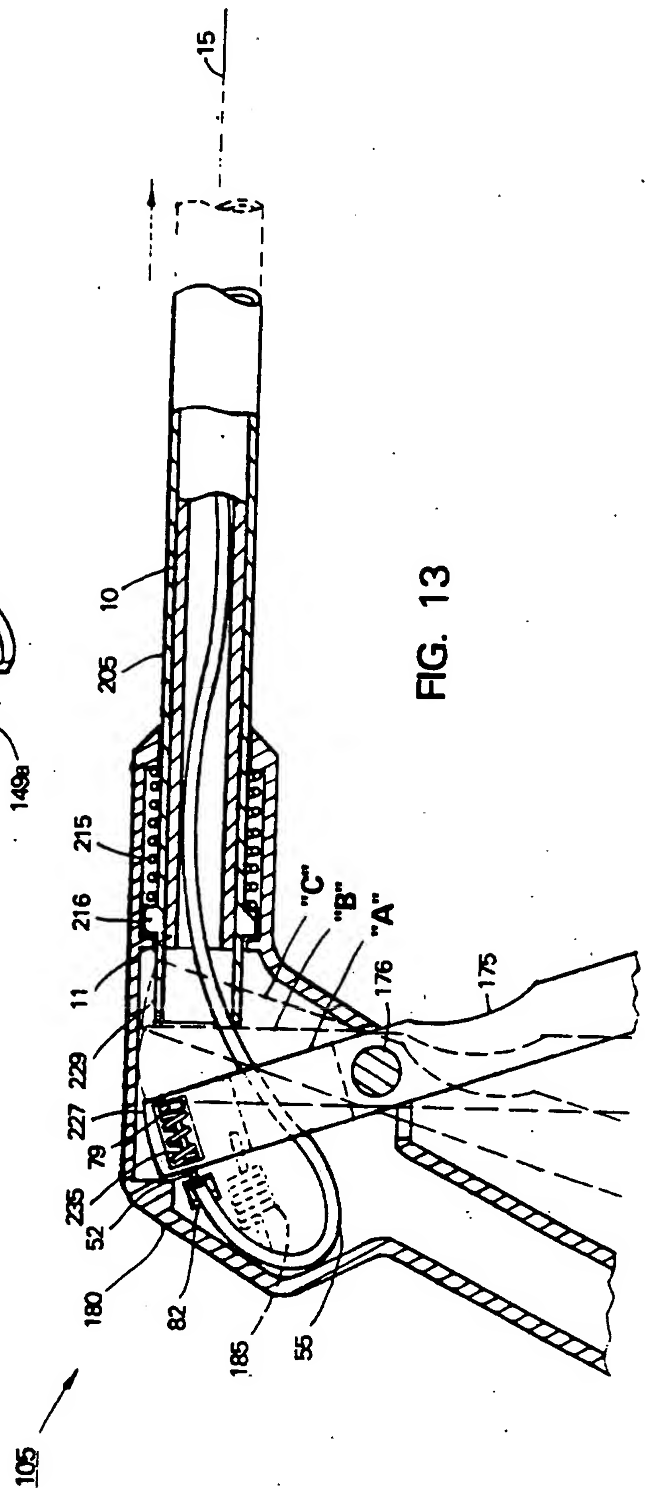
149a
132a
33a
70a

FIG. 12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"B"
"A"
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235
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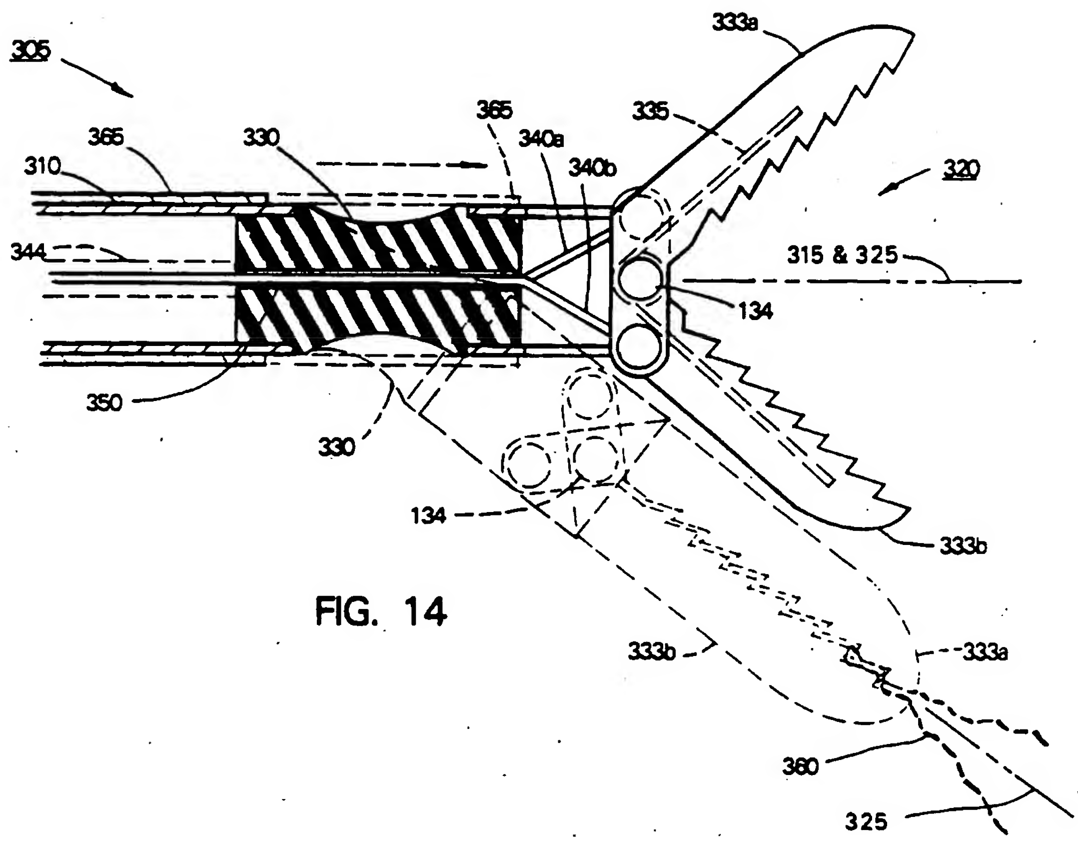
185
55
105

FIG. 13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365
340a
340b
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333a
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310
344
315 & 325
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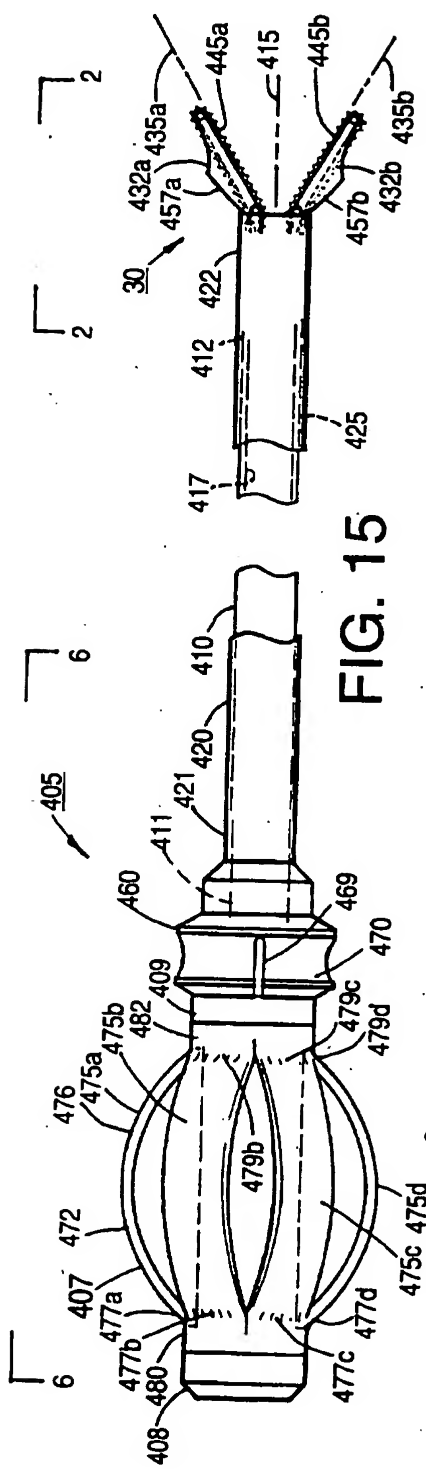
134
333b
333b
333a
360
325

FIG. 14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408
480
477b
477a
407
472
476
475a
475b
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469
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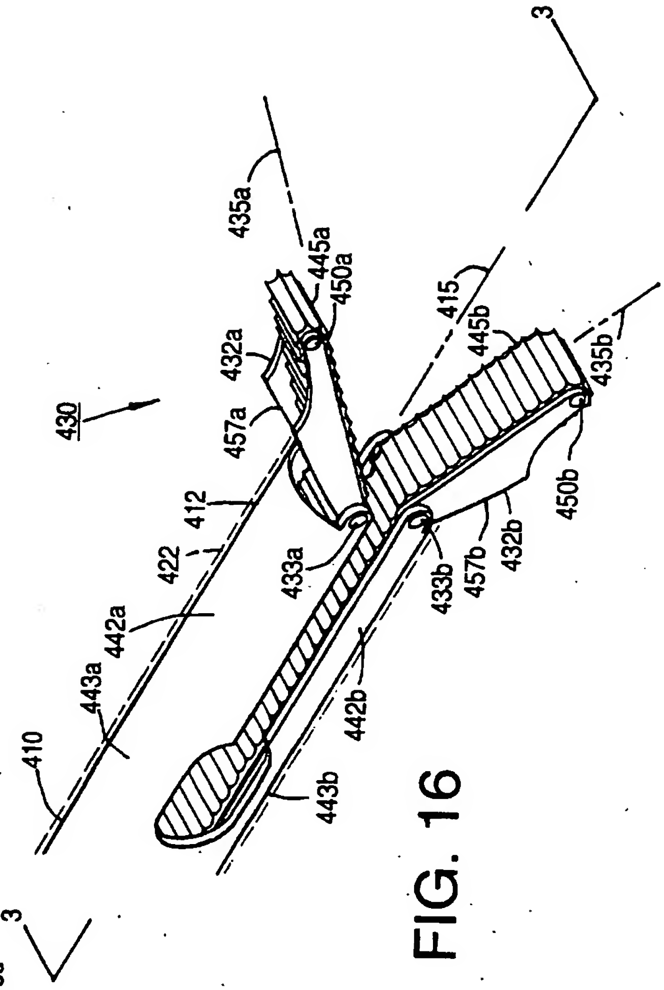
479c
479d
479b
475c
475d
477c
477d
3
FIG. 15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432b
457b
433b
442b
443b
FIG. 16

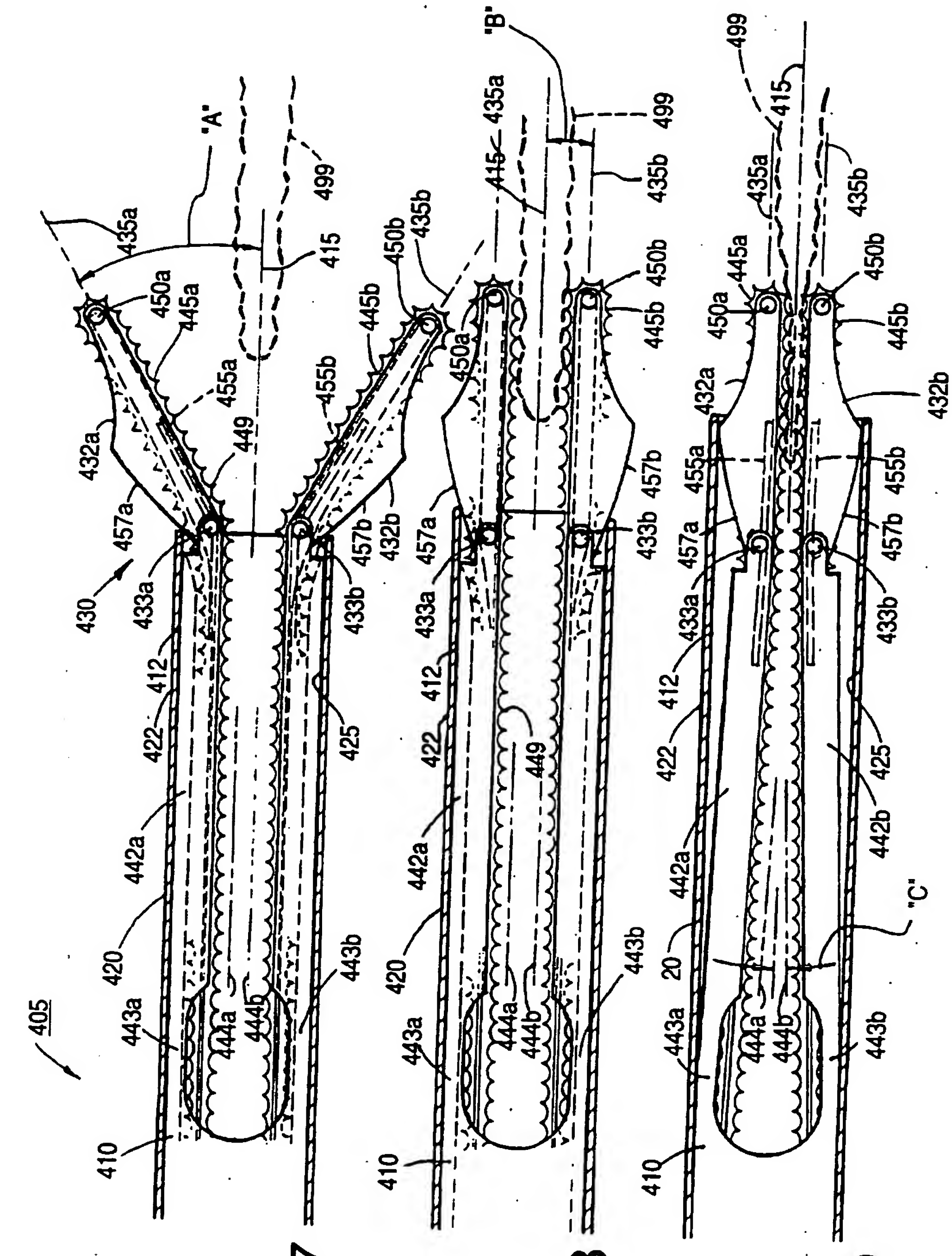
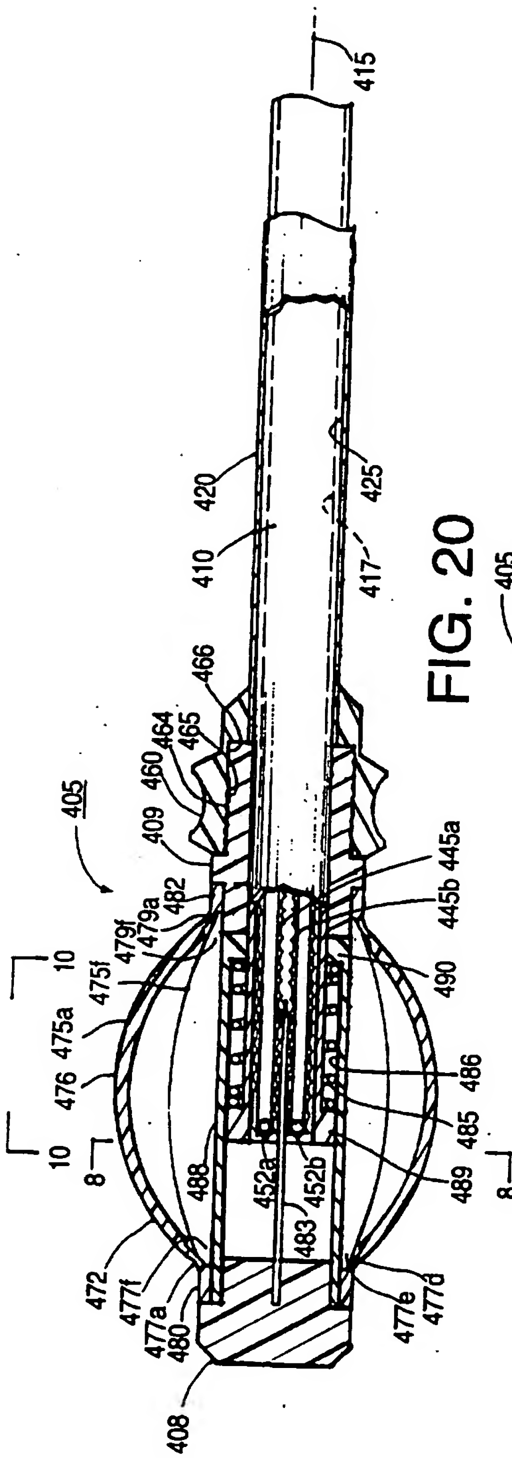


FIG. 17

FIG. 18

FIG. 19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460
409
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479a
479f
475f
475a
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10
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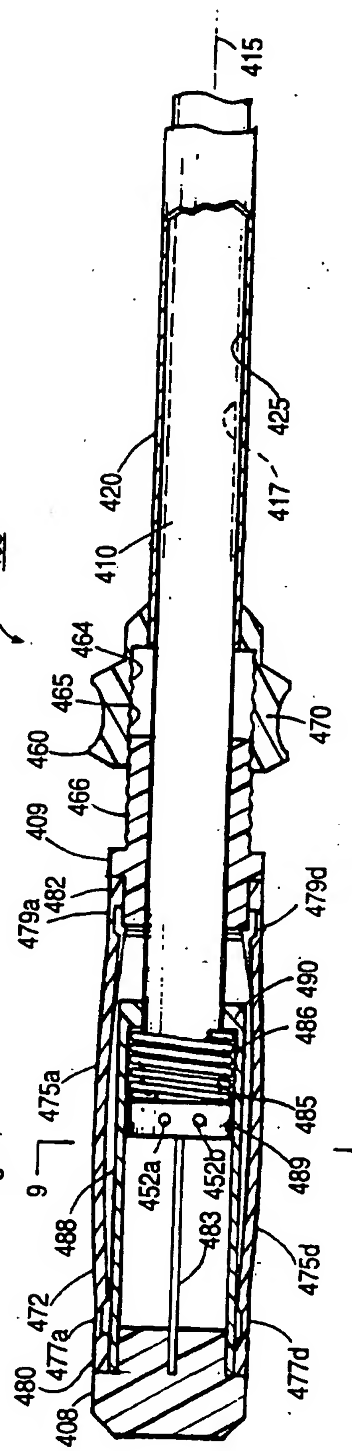
488
452a
452b
483
472
477f
477a
480
408
477e
477d
489
8
485
486
490
445b
445a

FIG. 20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479a
479d
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475a
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452b
452a
9
9
488
483
475d
472
477a
480
408
477d

FIG. 21

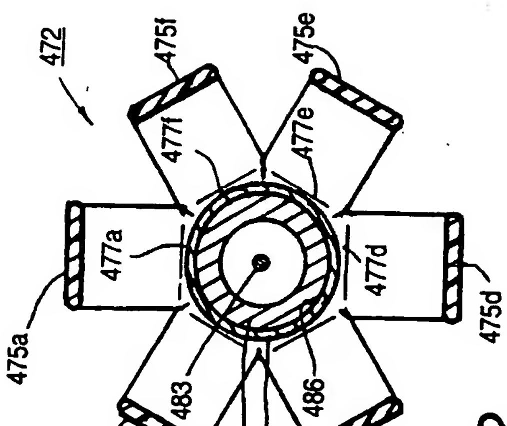



FIG. 22

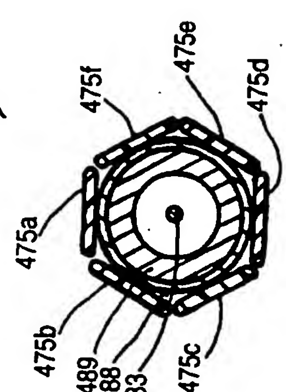



FIG. 23

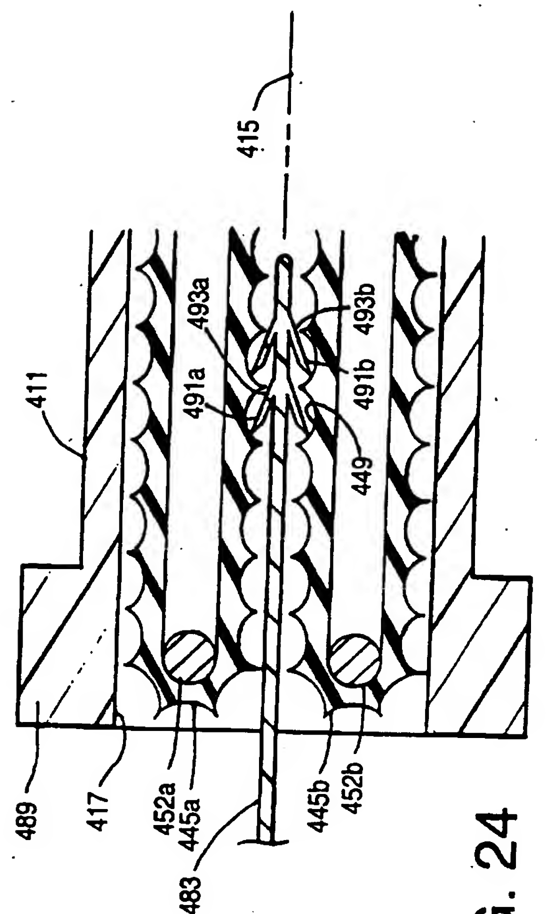
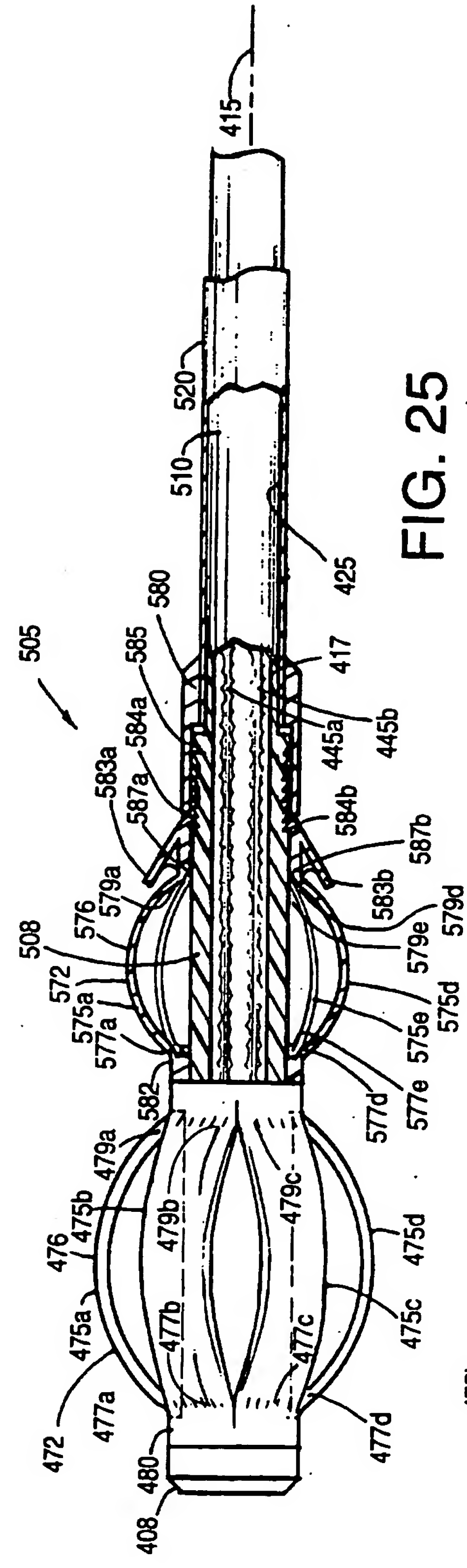



FIG. 24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587a
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579a
576
508
572
575a
577a
579d
579e
575e
575d
577d
577e
582
579a
479a
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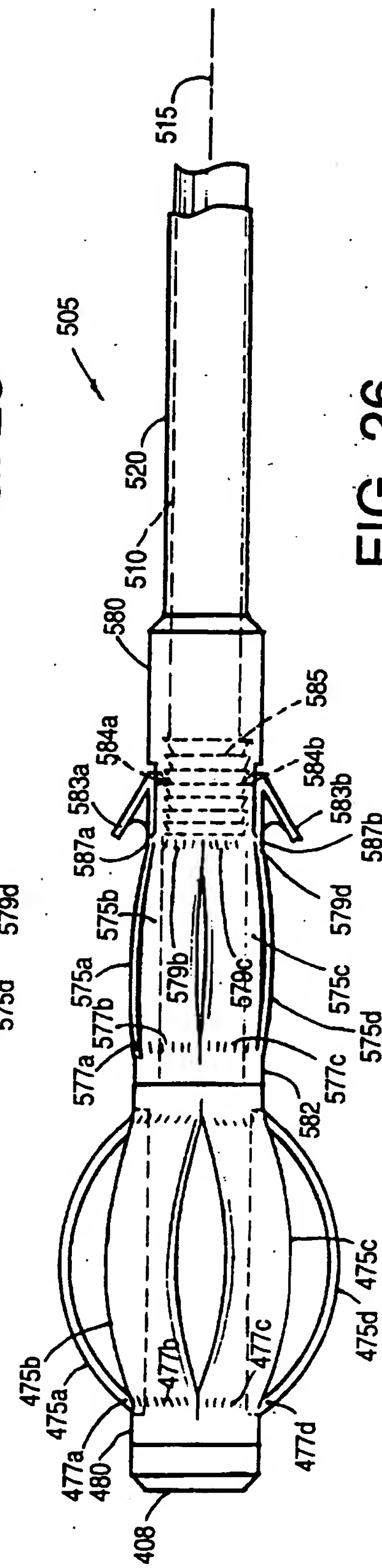
479b
479c
476
475d
475a
477b
477c
475c
472
477a
477d
480
408

FIG. 25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575c
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575d
577a
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475d
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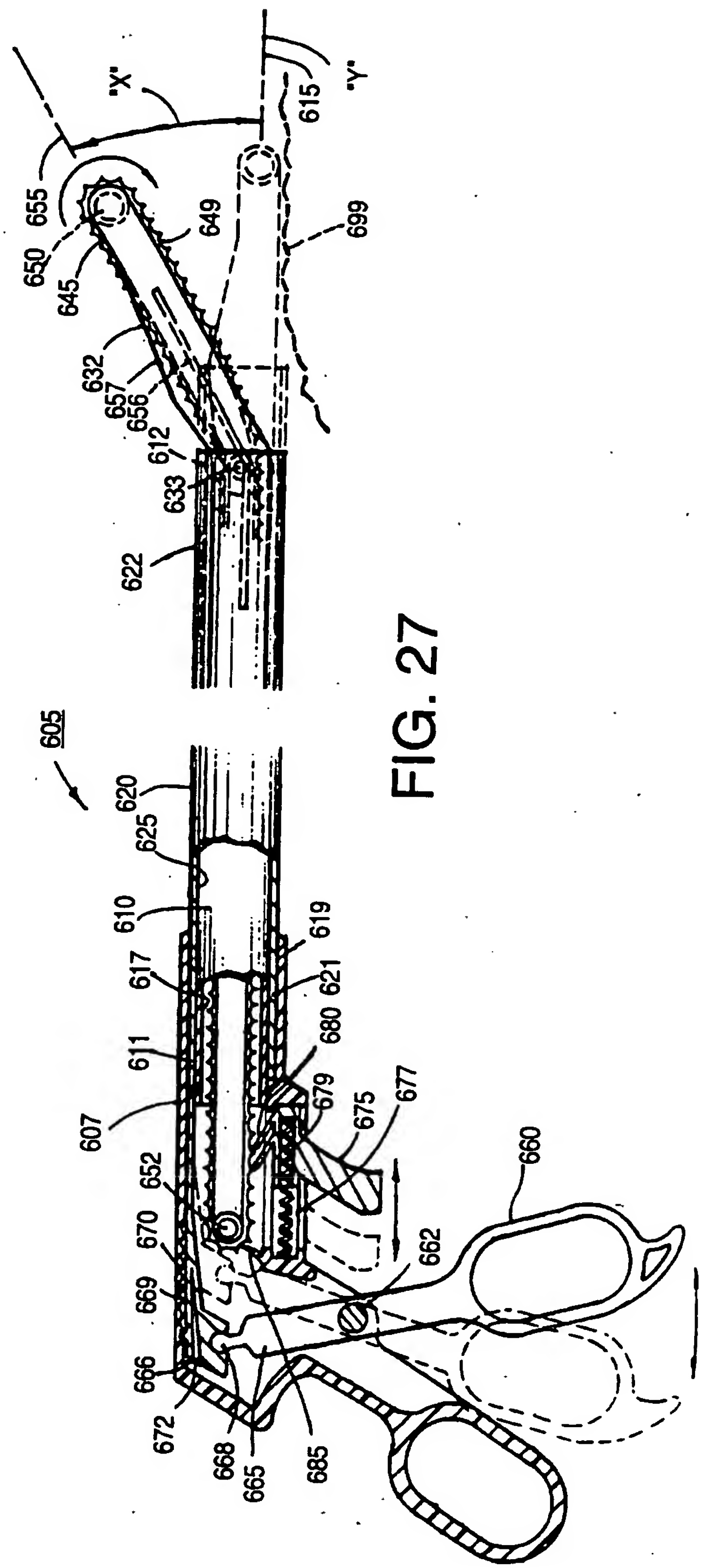
475a
477b
477c
477a
480
477d
408

FIG. 26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669
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668
665
685

FIG. 27

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/12523

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :A61B 17/28, 19/00
US CL :128/898; 606/205-207

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/749-754, 898; 606/1, 138-147, 151, 167, 170, 205-209

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>---<br>Y | US, A, 5,209,747 (KNOEPFLER) 11 May 1993, see entire document. | 1, 3, 6, 8, 11, 13, 16, 27<br>---<br>25, 26 |
| X<br>---, P<br>Y | US, A, 5,383,888 (ZVENYATSKY ET AL.) 24 January 1995, see entire document | 1, 3, 6, 8, 11, 13, 16, 27<br>---<br>25, 26 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

| | |
|---|---|
| Date of the actual completion of the international search<br>27 DECEMBER 1995 | Date of mailing of the international search report<br>29 JAN 1996 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. (703) 305-3230 | Authorized officer<br>GLENN K. DAWSON<br>Telephone No. (703) 308-4304 |

Form PCT/ISA/210 (second sheet)(July 1992)*